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MARCH — 1928

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PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MEETINGS

of the

American Institute of Electrical Engineers

ST. LOUIS REGIONAL MEETING, District No. 7
(March 7-9, 1928)

BALTIMORE REGIONAL MEETING, District No. 2
(April 17-19, 1928)

NEW HAVEN REGIONAL MEETING, Northeastern
District No. 1 (May 9-11, 1928)

SUMMER CONVENTION, Denver, Colo.
(June 25-29, 1928)

PACIFIC COAST CONVENTION, Spokane, Washington (August 28-31, 1928)

For Future Section Meetings, see notices in this issue

MEETINGS OF OTHER SOCIETIES

National Electric Light Association
- *Southwest Division,* Biloxi, Miss., April 3-5, 1928
- *Nebraska Section,* Omaha, Neb., April 4-5, 1928
- *Southeastern Division,* Miami, Fla., April 11-14, 1928
- *Middle West Division,* St. Louis, Mo., May 9-11, 1928

American Electrochemical Society
- Bridgeport, Conn., April 26-28, 1928
- (Communicate with C. G. Fink, Columbia University, New York, N. Y.)

JOURNAL

OF THE

American Institute of Electrical Engineers

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PUBLICATION COMMITTEE

E. B. Meyer, *Chairman*, H. P. Charlesworth, F. L. Hutchinson, Donald McNicol, L. F. Morehouse

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JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

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Transatlantic Meeting

Time and distance were annihilated in a spectacular way when, for the first time in history, two gatherings of engineers, one in New York and the other in London, talked freely and easily to each other, and their remarks were heard by hundred of people gathered in the auditoriums in both cities as readily as if all the speakers were on the same platform.

A new era in the communication art was thus inaugurated during the Winter Convention of the American Institute of Electrical Engineers at which a joint session with the British Institution of Electrical Engineers was held. The occasion marks an important milestone in the history of engineering achievements, and adds further luster to the already brilliant accomplishments in the records of the participating societies. (A full account of this meeting appears elsewhere in this issue.)

It was not without a feeling of awe that the New York audience awaited the salutation of the Chairman, 3000 miles away, but the messages came from across the ocean so promptly, clearly and naturally that the novelty of the demonstration would hardly have been recognized if the locations of the speakers had not been known.

It is particularly gratifying and appropriate that these two great engineering societies, separated by the vast expanse of the Atlantic Ocean but bound together by the common ties of advancement of science, invention and engineering in the field of electricity for the good of mankind, should be the first to come together in this new form of international assembly, made possible through the developments in one of the branches of our own profession.

The deep significance and far-reaching importance of this meeting were reflected in the eloquent remarks of those who addressed the joint session, and in the resolution adopted at the meeting.

The following resolution was adopted subsequently by the Board of Directors of the Institute:

WHEREAS: On February sixteenth, 1928, there was held a Joint Meeting of the British Institution of Electrical Engineers, its attending members and guests being assembled at twenty-eight Victoria Embankment, London, England, with the American Institute of Electrical Engineers, convened in the Engineering Auditorium, New York, U. S. A., during which all of the proceedings were rendered perfectly audible to both assemblies by means of land and transoceanic communication channels made available through the cooperation of the American Telephone and Telegraph Company and the British Post Office; and

WHEREAS: This extraordinary demonstration, the first of its kind in history, was successfully accomplished only by the perfectly concerted efforts, not only of the American Telephone and Telegraph Company and the British Post Office, but also of all of the individuals concerned in its preparation; therefore it is

RESOLVED: That the Board of Directors of the American Institute of Electrical Engineers, on behalf of those members and guests whose privilege it was to attend the Joint Meeting, and also on behalf of the entire membership of the Institute, hereby expresses its thanks and its recognition of the efficiency, public spirit, and high technical achievement of these cooperating organizations as evidenced by this event; and especially extends its thanks and congratulations to the many technical assistants and workers without whose intelligent and faithful labors this proof of advance in applied science would have been impossible.

Engineering Education

A publication that will be of great interest to both practising engineers and engineering educators was issued in December 1927 by the Board of Investigation and Coordination of the Society for the Promotion of Engineering Education as Bulletin No. 13, entitled "Opinions of Professional Engineers Concerning Educational Policies and Practises."

As an important part of the general investigation of engineering education, special inquiries were made among a considerable number of the more influential engineers who are members of the national societies corresponding to the five principal divisions of engineering education. The lists of members used were chosen after consultation with the special committees and secretaries of the societies, and the societies cooperated in conducting the inquiries.

The results of a complete detailed analysis of nearly 1100 returns, including those from 271 prominent electrical engineers, are presented in this Bulletin. Parts I, II, and III relate to engineering education in general, containing "a summary of general inferences and conclusions, a summary of opinions on a group of specific educational issues, and a summary of opinions concerning the extent and means of the influence of the engineering profession in engineering education." Parts IV to VIII inclusive contain the results of the inquiries in each of the five principal divisions of engineering education and selected comments submitted by engineers of each group.

Conclusions derived from the replies of the electrical engineers are that electrical engineering curricula should not be sharply differentiated from those in other

divisions, and that the broad base of the curriculum should include mathematics, physics, English, drawing, mechanics, mechanics of materials, heat power engineering, hydraulics, economics, shop practise, and business law. The majority opinion is that economics should be emphasized but should be taught in engineering courses rather than separately. Only a small minority favored distinct curricula in certain divisions of electrical engineering. A larger influence in engineering education by the national societies was favored by many.

Copies of Bulletin No. 13 may be obtained from the Lancaster Press, Lancaster, Pennsylvania, at a nominal price of thirty cents each. Titles and prices of previous bulletins and reports published by the Board of Investigation and Coordination may be found in the JOURNAL for January 1927, page 83, and September 1927, page 858.

Some Leaders of the A. I. E. E.

William LeRoy Emmet, vice-president of the Institute 1900-1902, was born at Pelham, New York, July 10, 1859. In 1881 he was graduated from the U. S. Naval Academy and remained in the Navy for two years thereafter. For thirty years he worked earnestly and enthusiastically toward one goal—the mastery of obstacles that appeared to lie between engineering theory and its practical application. In this endeavor, he showed tenacity and fearlessness, his practical knowledge of operating conditions enabling him to weather discouragement. Apparent failure in principle only led Mr. Emmet to study details, for in the fullness of this knowledge he felt confident that he could perfect the fundamentals. In the analysis of a situation, either mechanical or human, Mr. Emmet was a master worker.

His was untiring energy and diligence of application. To offers of high salaries and positions of executive importance he turned a deaf ear, preferring to remain among the yet unsounded engineering problems rather than assume the direction of the better explored endeavors. In 1887 he joined the Sprague Electric Company, then coping with electric railroad developments in Richmond, Va., Harrisburg, and other cities throughout the country. In 1889 he was sent to Pittsburgh to superintend the Sprague Electric Company's installation, one of the largest electric railroad operations of the time. Mr. Emmet, with his characteristic determination, tackled the work, rewound motors, reinsulated coils, devised new methods of attaching the brushes—methods which afterward became historic in electrical development—and invented a new system of insulating armature coils.

In 1890 Mr. Emmet went with the Westinghouse Electric & Mfg. Co., but only for a short time. During his work with the Sprague Co., the R. D. Nuttall did much work from his designs on trolleys and electric railway devices used either in the Sprague Co. work or sold by Emmet to the Westinghouse Co. and to Electric Railways. This led to the Nuttall Co's. later activity in this field. About this time he was granted several patents on trolley devices and other supplies which later proved their worth in this field of application. Next he went to Buffalo to become electrical engineer for the Buffalo Railway Company, but went on almost immediately to Chicago as district engineer for the Edison General Electric Company, just formed. In 1892, this company transferred him to their New York Office and started him in as engineer in charge of the Foreign Department, later, again transfering him to the Lighting Department, where his most important professional work was begun. In was in 1900 that Mr. Emmet started his work in the development on the Curtis steam turbine, and in 1902 the first 500-kw. machine was installed in Newport, R. I. with great success. Three months later this was followed by a four-stage 3000-kw. machine which gave much greater economy and really put the turbine operations upon a firm basis, and by the end of the year, the first and famous 5000-kw. machine was installed in Chicago. It soon became of worldwide fame. Mr. Emmet was the first to point out the great importance of high vacuum in the operation of the turbine; he also initiated the use of the turbine for ship propulsion (1907) first, in two fireboats in Chicago, and in 1909 the first proposition was made to the United States Government for the operation of battleships. Of his work in the early development of a-c. generators, Mr. Emmet once stated that his greatest difficulty was the hunting of alternators operated in parallel by reciprocating engines. This apparent defect in the electrical apparatus he traced to the engine governors, but with a few changes which he suggested in the design, the trouble was speedily overcome. The first successful operation of a-c. generators was in Omaha, where 48-pole, 300-kw. machines were installed. In his turbine work, Mr. Curtis was of great assistance and support to Mr. Emmet. For the year 1919, he was the recipient of the Edison Medal for his "invention and development of electrical apparatus and prime movers."

Mr. Emmet has over a hundred patents on electrical and kindred apparatus to his credit. He is a member of the American Philosophical Society, the Society of Naval Architects and Marine Engineers, the National Academy of Sciences and has contributed much to technical literature, both by way of papers and longer works.

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Abridgment of

Surge Impulse Breakdown of Air

BY J. J. TOROK*

Associate, A. I. E. E.

***Synopsis.**—This paper describes a phenomenon which is used as a method of studying the development of high-voltage sparkover. It has been found that if a voltage which rises very rapidly to a value more than sufficient to cause breakdown, if continuously applied, is impressed upon a sphere-gap and this is very quickly reduced to a low value, luminous streamers are produced instead of the usual intense spark. These streamers can be observed with the eye and can be recorded on a photographic plate by the use of a quartz lens.*

The phenomenon described and recorded is of intense interest because it presents the intermediate stages between the initiation of and the actual flashover between the spheres.

The effect on time lag of flashover, with special reference to the state of ionization of the gas previous to flashover, is also discussed.

Beside giving information on the mechanism of development of sparkover, this method of "suppressed discharge" has been used to determine the nature of the electrostatic field about insulators and between electrodes of various shapes.

* * * * *

SEVERAL attempts have been made to extend the theory of ionization by collision, as developed by Townsend,[5] to account for the time lag of sparks. None has been successful in accounting for time lags of a shorter period than 10^{-7} seconds, which experimenters such as Pedersen,[8] Peek[9] and Burawoy[10] find to exist at atmospheric pressures and large gap lengths. *For the study of impulse characteristics, etc.*

For the study of impulse characteristics of gaps and other apparatus, it is necessary to have a controllable source of high-voltage impulses. Surges are usually produced artificially by discharging condensers through a resistance by means of a sphere-gap. The voltage piles up across the resistance which gradually discharges the condenser. The discharge may be a damped oscillation or a d-c. impulse, depending upon the value of the constants of the circuit. A surge generator of this nature, which the author used in studying time lags of sparks, was fully described by D. F. Miner.[12]

Visual Evidence of Time Lag

The study of time lag demands a knowledge of wave form of the impulse obtained from the surge generator. While attempting to determine the wave front of steep waves by reflection methods, the author noticed that occasionally a glow resembling a corona discharge occurred between the 75-cm. spheres used as a measuring gap. It has been generally accepted in low-frequency work that the sphere-gap flashover takes place without the initial corona formation that precedes a needle-gap flashover. The observance of this glow discharge led to a special study of the conditions under which it occurred.

The surge generator was connected directly to a transmission line 50 ft. long as shown in Fig. 1. The end of the line was grounded, thus causing the voltage at G_3 (75-cm. spheres) to be suddenly reduced when the wave reflected from the grounded end reached G_3; consequently, the voltage impressed on G_3 rose very steeply and then dropped very sharply as a result of the reflection at the end of the line. Under these conditions, when trying to measure the crest of the voltage with a 75-cm. sphere-gap at G_3, a glow, instead of a spark,

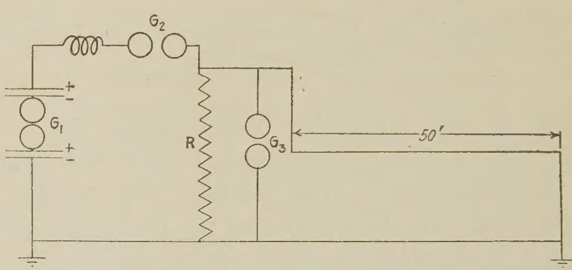
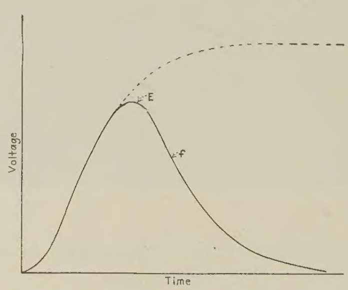


Fig. 1—Diagram for Using Transmission Line

appeared between the two spheres. This phenomenon showed that the voltage was reduced so quickly to a negligible value after ionization began that a complete spark was prevented from forming.

Improvement over Transmission Line

The voltage wave impressed upon the sphere-gap was then of the nature shown in Fig. 2. The ionization



Fif. 2—General Shape of Wave Impressed on Sphere-Gaps

by collision would probably start before E, but the developed spark might not occur until point f was reached, due to the time lag of the sphere-gap. If the voltage was brought to zero somewhat faster, the developed spark might not occur at all, even though the

*Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

1. For references see Bibliography.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

air between the spheres would be sufficiently ionized to cause a luminous glow. Since the wave shape obtained in this way had such a flat top, conditions were quite critical and therefore any slight overvoltage or decrease in the spacing of the spheres caused a complete breakdown, while if the voltage did not quite come up to that for which the spheres were set, no luminous discharge would occur at all. A less critical arrangement was found by using a second sphere-gap, G_4 Fig. 3,

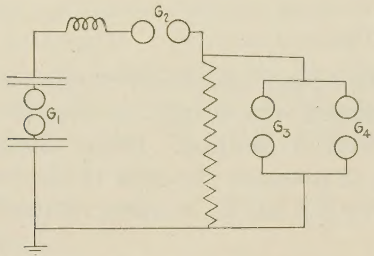


Fig. 3—Method for Utilizing Sphere-Gap Instead of Transmission Line

instead of the grounded transmission line. This circuit was a great improvement over the original one, as it was much more flexible. By varying the setting of the second sphere-gap G_4, it was possible to obtain a photograph of the discharge in the first gap G_3 in any stage of its development. The second sphere-

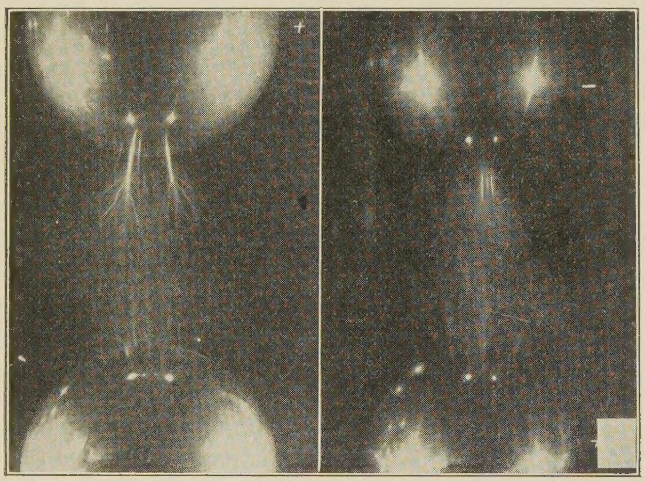


Fig. 4 Fig. 5

Fig. 4—A Typical Suppressed Discharge in which Cathode is Grounded

Fig. 5—Suppressed Discharge with Anode Grounded

gap reduced the voltage to a negligible value much more rapidly than was possible with the transmission line where the wave front was the controlling factor. An example of a discharge across the first sphere-gap obtained in this way is shown in Fig. 4.

From the known characteristics of the surge front, a fair conception of the time required for a streamer to bridge a 40-cm. gap was obtained. This time, using 75-cm. spheres, was found to be of the order of 10^{-8} seconds. The wave used had a rate of rise of approximately 5000 kv. per microsecond. Thus, knowing the sphere-gap settings (and their corresponding static sparkover voltages) at which suppressed discharges first appear and the maximum separation at which complete sparkover is obtained, the time elapsing between the two periods can easily be found.

Suppressed Discharges

Discharges of the nature shown in Fig. 4, or "suppressed discharges" as they might be termed, give much information concerning the process of breakdown. The bright streamers on the ungrounded positive sphere in Fig. 4 span only a portion of the distance between the spheres. The rest of the gap is bridged by a light purple haze. Differences in intensities of luminosity of various portions of the field indicate, in a rough way, that the state of ionization is not uniform throughout. It is probable that the bright anode streamers have already the properties of arcs,[13] while the haze extending from the ends of the streamers to the cathode is still a glow discharge. Evidently, then, the break-

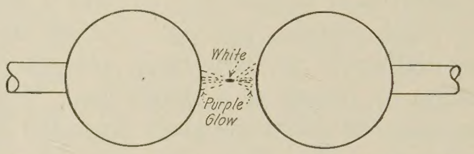


Fig. 6—Formation of Streamers in Space Between Electrodes

down starts at the most intense portion of the field (assuming a uniform density of free electrons throughout the field) and progresses into the field until it meets a streamer developing from the electrode of opposite polarity. In the case of sphere-gaps, when one sphere is grounded, the gradient at the surface of the ungrounded sphere is much higher than the gradient on the grounded sphere. This fact is clearly illustrated by Figs. 4 and 5. In Fig. 4 the cathode is grounded, while in Fig. 5, the anode is grounded. The streamers on the grounded sphere have developed but little, showing a weak field at that point. These figures indicate rather clearly that a spark develops from a dark current to a glow discharge which in turn assumes the properties of an arc at points where the current densities are highest.

Suppressed discharges have been obtained on gaps varying from 0.25-cm. to 75-cm. spacing. 6.25-cm. spheres were used for voltages ranging below 100 kv. crest, then for potential ranging between 100 kv. and 500 kv., 50-cm. spheres were utilized. For all voltages above 500 kv., 75-cm. spheres were used. While observing these discharges on small spacings, (0.25 cm. to 2-cm.), several discharges occurred which had their intense streamers in the center with a faint glow extending from both ends to the electrodes. Fig. 6 illustrates this phenomenon.

This type of discharge was obtained only after several lower-voltage surges, not resulting in breakdown of the air, were impressed on the spheres. Several explanations for the phenomenon were considered, the following two being the most logical; first, that the location of the first streamer is a matter of probability, and the resulting variability in its location becomes more marked as the initial number of free electrons in the field diminishes; second, that a current of air carries out the air ionized by application of voltage below the breakdown value, replacing it with air containing the normal number of free electrons. The surface friction prevented the air next to the electrodes from being swept out. When a surge of higher amplitude than the rest was applied, the air in the center of the gap became ionized to a higher degree than that at the surface, due to the greater initial number of free electrons at that point. As ionization progressed, a streamer formed in the center, but before it could reach either electrode, the voltage was reduced by the suppressing gap.

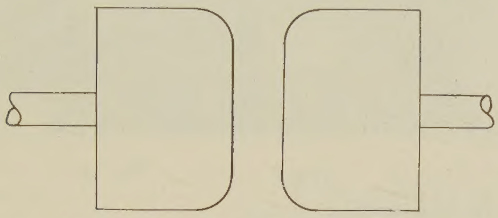


Fig. 7—Electrodes Used to Obtain Homogeneous Field

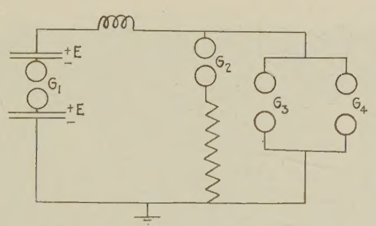


Fig. 8—Scheme for De-Ionizing Air Between Spheres by Condenser Potential

Should the second explanation be correct, it would mean that the breakdown, (at least with very steep surges and normally ionized field), is not produced by electrons traversing the entire field but that each portion of the field is ionized separately by the local ions, these sections being joined together as the streamer progresses.

Using spherical electrodes this phenomenon was reproduced quite often, *i. e.*, 1 out of 10 times. Again when the field distribution is considered it is difficult to attribute this type of suppressed discharge to probability. The highest gradient is at the surface of the spheres, while the gradient at the center is appreciably lower; thus the velocity of the electrons and positive ions will be higher near the surface than in the center and more electrons will be produced there. With higher density of free ions near the surface, the probability of the arc originating at the center would be much less. When however, electrode of the type shown in Fig. 7 was used, the phenomenon occurred 3 out of 10 times, the gradient throughout the field being more nearly homogeneous than with spheres, which gives the probability theory more weight.

The Effect of Varying the Initial Density of Ions

The original number of ions in the field can be varied by two means,—controlling a source of ionization and by drawing the free ions out of the field. The latter can be effected by impressing a constant voltage below breakdown value on the electrodes. In applying the first method, soft X-rays were used to ionize the field. The set-up used is shown schematically in Fig. 8. Gaps G_3 and G_4 had a constant potential impressed upon them, which in this case is always the condenser charging potential E. When G_1 broke down the two banks of condensers were thrown in series, impressing $2E$ on gaps G_2, G_3, and G_4. In this manner, surges were applied to sphere-gaps which were constantly excited. Under these conditions the number of ions in the field just before breakdown was reduced to a very small quantity. G_3 was set slightly above the breakdown value of G_1 so that G_1 would break down before G_3. G_4 was used to measure the voltage and, under suitable conditions, would show suppressed discharges appearing across G_3. The results of this test are tabulated in Table I. Under these conditions, suppressed discharge at G_4 could rarely be obtained, and even then, the glow at the ends of the streamers was very faint. The maximum voltage indicated by G_4 was 66 kv. X-rays were directed on G_4 Fig. 8 to increase the ionization in the gap. Now, however, the spacing in G_4 has to be increased to 3.18 cm. before complete breakdown ceased. This setting corresponds to 81 kv. Suppressed discharge appeared up to a separation of 3.8 cm. or 89 kv. The glow at the tips of the streamers was now very

TABLE I

	G_1		G_3		G_4		
Conditions	Sep. in. cm.	Kv.	Sep. in cm.	Kv.	Sep. in cm.	Kv.	Remarks
Excited No X-rays..	1.68	50	1.9	57	2.33	66	Complete flashover on G_4 ceased at 2.33-cm. spacing and suppressed discharge occurred very seldom above that value.
Excited X-rays on G_4	1.68	50	1.9	57	3.18 3.8	81	Complete flashover ceased on G_4 for separations above 3.18 cm. but suppressed disharge appeared from 3.18 cm. to 3.8 cm.

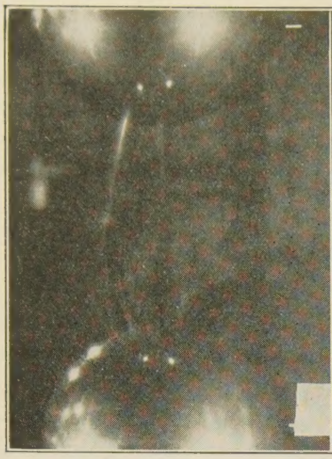
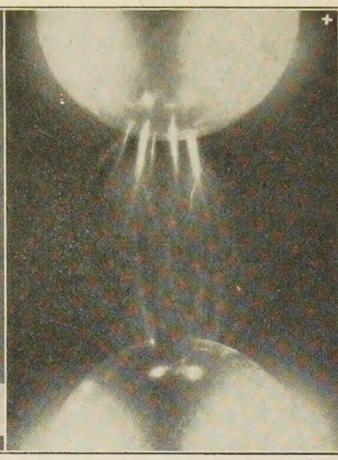
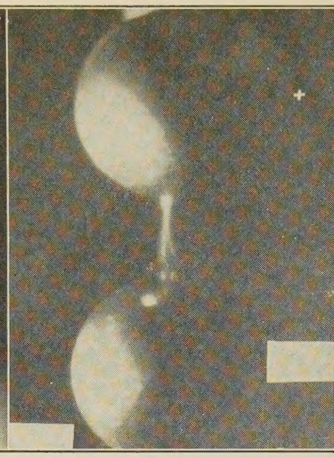





Fig. 9 Fig. 10 Fig. 11 Fig. 12

Figs. 12, 13, 14, 15—Successive Stages of Breakdown of Air

12. Early stage
13. Secondary stage
14. Space almost spanned by streamers
15. Complete discharge

pronounced. These two tests indicate rather strongly that the time lag of sphere-gaps is a function of the number of ions in the field when the surge is applied. The prominence of the glow at the ends of the streamers in the case of previously ionized gaps, together with the increase of speed of breakdown, is in full accord with the assumption that the free ions originally in the field produce numerous ionized sections which finally join to form streamers. The rapidity of development of these streamers might be taken as a function of the number of these ionized sections.

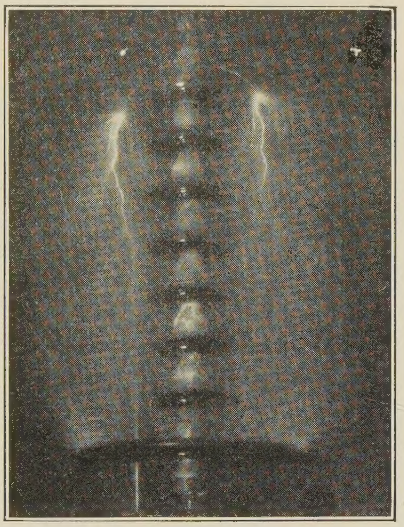


Fig. 13—Electrostatic Field Around Insulators Modified by Arcing Ring and Arcing Horn

Electrostatic Field Determinations

It seems possible to study the progressive stages of breakdown by the *suppressed discharge method.* This will yield important information as to the character of breakdown with various type of apparatus.

Figs. 9, 10, 11, 12 were selected from a large number of tests as representing progress of breakdown from initial streamer formation to arc-over.

One application of the suppressed discharge which has proved useful in engineering work is shown in Figs. 13 and 14. A picture of the electrostatic field surrounding an insulator string at the time of impulse application is produced, and shows the corrective or destructive effect caused by use of special transmission fittings. In Fig. 13 a horn was used at the top and a ring at the bottom of an eight unit string. The concentration at the horn tips is shown and also the drawing-in of the field at the top of the string. This leads frequently to cascading flashover. In Fig. 14 two arcing rings were used, and the field is much im-

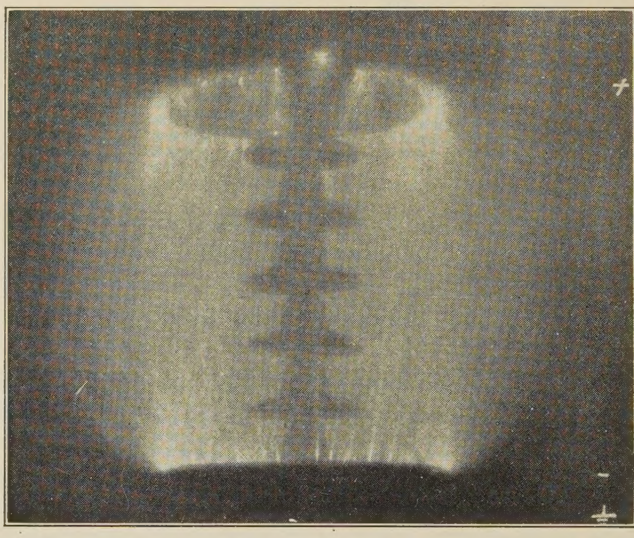


Fig. 14—Field Around Insulators as Improved by Circular Arcing Rings

proved. A flashover clear of the string will result from this field.

The writer wishes to express his appreciation to Dr. J. Slepian for many suggestions and comments, which have been of great assistance in carrying on this work and in preparing this paper; also to Messrs. Fortescue and Tenney for their valuable criticisms.

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Abridgment of

Thermal Volume Meter

BY G. W. PENNEY[1] and C. J. FECHHEIMER[1]

Synopsis.—*The thermal volume meter was originally brought out by Professor Thomas, and is frequently called a "Thomas Meter." The principle is that the temperature of the gas is raised by means of an electric heater, the change in temperature being accurately measured either by means of resistance thermometers connected in a wheatstone bridge network, or by means of a thermopile. It is believed that the thermocouple method is preferable to resistance thermometers, and most of the paper deals with that construction.*

The usual construction has walls of wood or micarta which serve as an insulating support for the heater coils and thermocouples. The paper deals with the general proportions of the volume meter as to section and length, the former being determined mainly by the mean velocity of the air, and the latter by the distance needed to give the gas an opportunity to mix after passing the heater. A sufficient number of thermocouples is required to give a good reading of the potentiometer with a comparatively low temperature rise of the gas and also to obtain a good average of the gas temperature. The details of construction are described. Equations suitable for calculating the volumes of the gas are then given.

Then follows considerable discussion on the possible sources of error in the meter, the principal ones being:

a. The non-uniform heating of the gas.
b. Non-uniform distribution of velocities.
c. Heat escapement.

Methods are suggested for determining the magnitude of these experimentally or by calculation. There are several minor sources of error, such as:

1. *Time lag of meter.*
2. *Unsteady source of e. m. f.*
3. *Instrument errors.*
4. *Heat flow along thermocouple wires.*
5. *Loss of pressure in passing through the meter.*
6. *Variation of specific heat and humidity.*

Most of these are shown to be of negligible effect.

Some notes on design are given, which include means of calculating the proportions of the heater.

In Appendix I the advantages and disadvantages of various methods of measuring gas volumes are included. In Appendix II will be found some notes on comparison of resistance thermometers and thermocouples for temperature measurement. In Appendix III consideration is given to the electrical machine as a thermal volume meter.

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1. Introduction

There are many ways of measuring the volume of flow of gases, each having advantages and disadvantages. The more important of these methods are given in Appendix I, together with reasons why they are not generally well adapted for the measurement of air volume passing through electrical machinery. With most of the more accurate methods, the principal objection is that the pressure drop is so great as to reduce the volume considerably (*e. g.*, the orifice method). In the thermal volume meter, this objection is met by using a short duct in which the velocities are only moderate and the obstructions very small so that the resistance to flow is very slight

The thermal volume meter was first brought out by Prof. Carl Thomas, and is frequently called a "Thomas Meter."

The principle of operation of the instrument is that the temperature of the gas is raised, the temperature increase and the amount of heat required to produce that change in temperature being accurately measured. As the specific heat at constant pressure has been accurately determined, the mass of the gas flowing per unit of time can then readily be calculated. As most engineers are more interested in the volume than in the mass, the change to volume can readily be made, if one has a knowledge of the absolute pressure and temperature. In practise, the gas is heated electrically. The temperature increase is measured by one of two methods: (1) By means of resistance thermometers

1. Both of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at Winter Convention of A. I. E. E., New York, N. Y., Feb. 13-17, 1928. Complete copies upon request.

placed before and after the heater, and used as two arms of a wheatstone bridge; and (2), by means of thermocouples connected in series (frequently called a thermopile). A comparison of these two methods of temperature rise measurements is given in the complete paper. It is believed that the latter method, using thermocouples, is preferable. The following description pertains to that type.

In this paper the experiences of the authors and their co-workers at the Westinghouse Company are given; there is very little in the technical literature on the subject with which to compare.

Some of the material in this paper has appeared elsewhere, but as it is scattered, it was thought best to combine it with that which has not previously been published.

2. Construction of the Thermal Volume Meter

As electrical conductors are used for the heater and for the temperature measuring devices, the construction is simplified by the use of electrical insulator material for the walls. This has an additional advantage, since an electrical insulator is usually a poor heat conductor, and to secure accuracy, it is essential that escapement of heat from the outside be avoided. In all but the smallest sizes, pine or maple wood has been used; and for the smaller sizes, such as is shown in Fig. 1, micarta

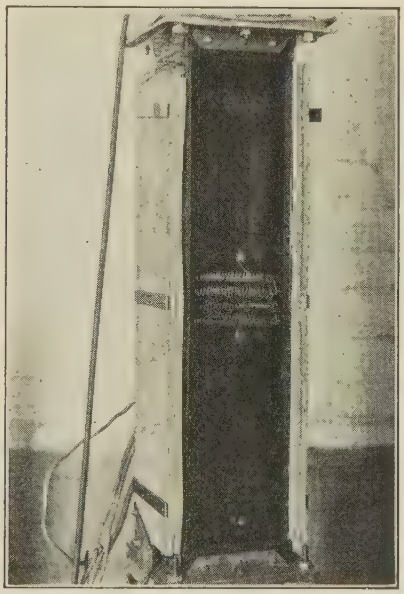

Fig. 1—A Small Volume Meter With One Side Removed for Inspection

plate was the material adopted. The walls are then thermally "insulated" with cork board. In the larger sizes, with wooden walls about one inch thick and with internal temperatures of the air not over 5 deg. cent. above atmospheric temperature, it was found that the heat loss from the outside was negligible, even though there was no heat insulating material added to the exterior. This heat loss can be calculated sufficiently accurately to determine whether or not insulating material should be added, and how much.

Fig. 1 shows a small meter, with one side removed for inspection. Its inside dimensions are 3½ in. by 3½ in. by 18 in., and it is suitable for handling from 60 to 300 cu. ft. per min. approximately.

The heating element usually consists of coils of wire, wound like coil springs and stretched across the volume meter. Screw eyes are used for holding the coils in place, but in order to secure uniform heat distribution, the screw eyes must hold the coils very close to the

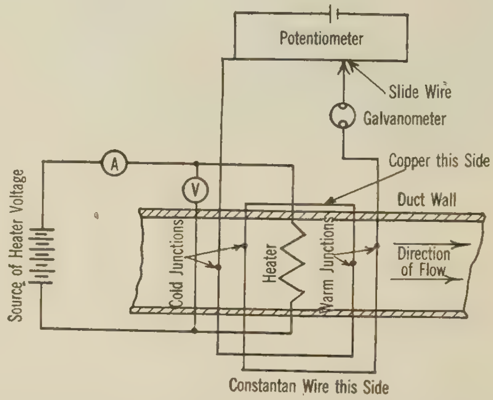

Fig. 3—Wiring Diagram of a Volume Meter

walls. The wire of which the heater is formed should not be passed through a thick wooden wall, as this portion of the wire would then have very poor heat dissipation and might reach a temperature sufficient to set the wood on fire. A brass bolt is frequently used as a terminal for carrying the current through the wall to the heater, and the heater should be large enough to allow a small temperature rise. Ordinarily this has been limited to a 50 deg. cent. rise in order to have a negligible amount of heat radiated to the walls and thermocouples. The distance between the heater coils and the thermocouple junctions depends largely upon how far the gas must flow to mix fairly well; it has been the authors' practise to make that distance at least as great as the mean proportion of the two cross-sectional dimensions for the large meters, and about two or three times as great for the smaller meters.

The number of thermocouples used has never been less than 16, and usually the number is more. With a large number of thermocouples, a good average of the temperature increase of the air is obtained and a fairly high reading of the potentiometer is secured. Thus, with 40 microvolts per deg. per couple, and with 25 couples, a reading of 2 millivolts is obtained with only 2-deg. cent. increase in air temperature. In arranging the locations of the thermocouple junctions, the rectangular area is broken into as many equal squares as there are thermocouples, and a junction is placed in each square. The scheme of connections is shown in Fig. 3, where, for simplicity, two thermocouples are shown. The junctions are usually made by slightly overlapping the wires, and then, silver soldered; or in larger meters, they may be made by twisting the

wires and then soft soldering. It is important that the thermocouples placed in the cool stream be at the same distance from the heater as those in the warmed gas. Otherwise, heat radiation will play its part unequally, thereby introducing a large error, even when the heater coils are at a comparatively low temperature. In dry weather, static electricity has been known to affect the reading of the potentiometer, and it is well then to ground one of the thermopile leads.

3. Equations for Computing Volumes

It may be shown readily that

$$Q = \frac{0.03155}{\gamma C_p} \frac{W}{\theta} \tag{1}$$

Here Q = cu. ft. per min. of the gas.
γ = density in pounds per cu. ft.
C_p = specific heat at constant pressure.
W = watts absorbed by the gas.
θ = temperature rise of the gas.

For dry air, the density at 25 deg. cent. and 29.92 in. of mercury may be taken as 0.074, and the specific heat as 0.2418. Then for such conditions,

$$Q = 1.765 \frac{W}{\theta} \tag{2}$$

For any other than standard conditions, the law of a perfect gas may be used, so that then:

$$Q = 1.765 \left(\frac{273 + t}{273 + 25}\right) \frac{29.92}{P} \frac{W}{\theta}$$

$$= 0.177 \left(\frac{273 + t}{P}\right) \frac{W}{\theta} \tag{3}$$

Here, t is the temperature of the air, deg. cent., and P is the total pressure in inches of mercury.[2] The influence of humidity is so small that it may well be neglected. The order of error is discussed under "Sources of Error."

If E = microvolts per deg. from a calibration curve of the thermocouples, n = number of pairs of junctions, and e = reading of potentiometer in millivolts.

$$\theta = 1000 \frac{e}{n E}$$

Substituting this value in Eq. (3) and adding the correction for variation from standard temperature and pressure gives

$$Q = \frac{0.177\, n\, E\, W}{1000\, e} \cdot \frac{(273 + t)}{P} \text{ cu. ft. of air per min.}$$

2. It will readily be seen that the volume per unit time changes with the density as the gas passes through the apparatus. The particular values of t and P to be used in equation (2) are those corresponding to the location where the value of volume is desired:—this might be ahead of, behind, or within the meter. In most cases, the differences in density at various locations are so small as to be negligible.

4. Possible Sources of Error

The principal sources of error are (A) non-uniform heating of the gas; (B) non-uniform distribution of the gas; and (C) heat escapement.

A. Non Uniform Heating of the Gas. This has previously been mentioned. To discuss this, it is assumed that the velocities are uniform throughout the section. It is manifestly impossible to secure uniform distribution of loss in the heater coils, for in order to do this it would mean that the heater would cover the entire section. By making the volume meter fairly long the gas has more of a chance to mix after it has passed the heater. It is believed that the heater coils tend to produce some turbulence in the gas stream, which assists in mixing the gas. Then, by employing a large number of thermocouples, the error becomes practically negligible. In some of the tests, the e. m. f. per thermocouple was measured, which was easily done by removing the insulation from the joints of the series connections on one side of the meter, and then using a sensitive potentiometer and galvanometer for balancing. It was usually found that there was considerable variation in e. m. f. per couple, but with a large number of couples, the average of the readings was so close to the true average that the error was very small. For example, the volume meter shown in Fig. 1, with 20 thermocouples, was checked against a converging nozzle, designed in accordance with data in the paper by Dr. S. A. Moss.[3] In three sets of readings, in which the air was heated 3 deg. to 6.8 deg., the difference, between the nozzle and volume meter readings were +0.4, −0.8, and −1.5 per cent, the plus sign meaning that the volume meter read high. Yet readings of individual thermocouples varied from 0.040 to 0.105 millivolts, with an average of 0.0827 millivolts, thus showing 51.5 per cent below, and 27 per cent above the mean. In this case, the velocity distribution was very good, the error due thereto being probably less than 0.3 per cent.

B. Non-Uniform Velocity. In the forgoing where non-uniform heating was considered, it was assumed that the velocities were uniform throughout the meter. In general, that condition cannot be obtained, but it can be approached close enough to reduce the error due thereto to negligible magnitude. The effect of non-uniform velocities is different from non-uniform heating. Thus, assuming uniform heat distribution, the temperature increase of the gas as it passes through the heater coil is nearly inversely as the velocity. On the other hand, if the velocities are uniform, the temperature increase is directly proportional to the heat per unit of area. It is because of the reciprocal relation with velocities that great departures from uniformity should be corrected. In some of the earlier tests, it was found that the air in some

3. "The Impact Tube." American Society of Mech. Eng. 1916.

small areas actually moved in the reverse directions to the main air streams. Then the cool and warm thermocouple junctions were reversed, and a very large error was introduced. It is not essential that the velocities be uniform, but the departures should not cause the errors in measurement to be more than about one per cent. Then there may be considerably greater irregularities than for, say, pitot tube measurements.

If the sectional area of the duct be broken into a number of small but equal areas, through any one of which the velocity is considered uniform, and those velocities be assumed to obtain throughout the length of the volume meter, then the ratio of the volume that would be measured were the velocities uniform to the volume that is measured, is given by[4]

$$R = \frac{(\Sigma V)\left(\Sigma \frac{1}{V}\right)}{n^2} \tag{9}$$

Here, V is the velocity in the small section, and n is the number of sections; that is, multiply the volume as measured by R to obtain the correct volume.

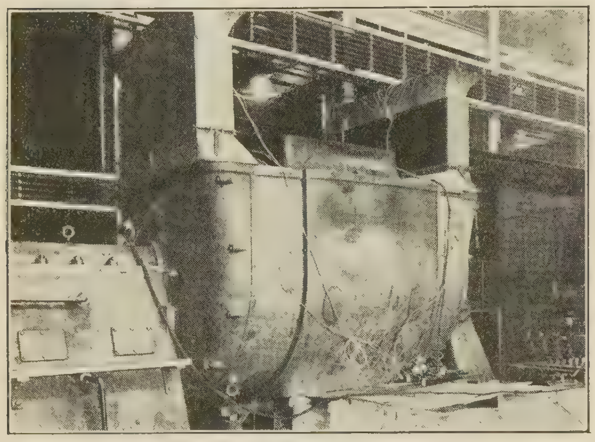

Fig. 6—A Small Turbo Alternator with Volume Meters Attached

Thermocouples were also provided for measuring temperature rise of the air through the machine.

If the volume meter discharges into the atmosphere or if the duct leaving the volume meter can be removed, an impact tube may be used to determine the approximate velocity distribution over the cross-section. In other cases it may be necessary to insert a pitot tube through a hole in the duct wall to determine the velocity distribution. The velocity should be sufficiently uniform so that the error as given by equation (9) is not serious. When the air is to be taken directly into the volume meter from the atmosphere, the vena contracta, arising from sharp entrance conditions, should be avoided, and a suitably curved converging intake should be provided such as is shown in Fig. 6. It should be especially noted that an obstruction, or sudden bend, within, or just head of, the meter may produce very poor velocity distribution, and should be avoided. A fairly long straight duct ahead of the volume meter will usually give a satisfactory velocity distribution.

C. Heat Escapement. To secure accurate measurements, all of the heat generated in the heating coils must be absorbed by the gas passing through the meter, and the heat loss from the walls must be of no consequence. In a moderate sized meter with walls of wood which has a low thermal conductivity and with slight differences between internal and external temperatures, the loss of heat from the surface is usually negligible. But in small meters having perimeters that are large in relation to the cross-sectional areas and with walls of thin micarta, the heat loss from the surface may introduce a serious error, especially if heated air is being passed through the meter. This error may be made negligible by covering the meter with several layers of cork board.

Minor Sources of Error.

a. Time Lag of Meter.

In any thermal device, time is required to reach a steady state of temperature. Unlike most devices, this time usually increases as the size of the meter decreases. In the larger volume meters the thermocouple e. m. f. can be read in less than a minute after the current value is fixed, while in a very small meter it has been found necessary to wait more than 10 min. This might not be objectionable if all other conditions were constant but with a fluctuating room temperature (*e. g.*, in a room with a door opening to the outside), or with a slightly fluctuating voltage supply to the heater, an appreciable time lag in the meter may make it almost impossible to obtain accurate readings.

b. Influence of Variation in Specific Heat and Humidity.

Errors introduced by neglecting the influence of change of specific heat with temperature, and of various percentages of humidity are very small, and it is believed that for practically all engineering work, their effects upon volume meter readings may be ignored. According to Mark's Mechanical Engineers Hand Book, the specific heat of dry air at 10 deg. cent. is 0.2412, and at 50 deg cent., it is 0.2422, a difference of only 0.41 per cent, over probably a greater range of temperatures than will usually be encountered.

As to humidity, the density decreases and the specific heat increases the greater the humdity, the product of the two changing very little. At 25 deg. cent. and 29.92 in. of mercury for dry air the product is 0.07403 by 0.2418 = 0.0179. For 100 per cent moisture, it is 0.07317 by 0.2462 = 0.01801. The difference between these two products is only 0.6 per cent, for greater extremes than will be found in test.

4. The derivation of this equation is given in the Appendix of paper "Performance of Centrifugal Fans for Electrical Machinery," A. S. M. E. 1924.

Abridgment of

Automatic Control of Edison Systems

As Applied in the St. Charles Street Substation of the Union Electric Light and Power Company

BY O. J. ROTTY* and E. L. HOUGH†

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—A brief description of the Edison System at St. Louis is given, and power supply, service restoration, and system balance are discussed.

The relation of the St. Charles St. Substation to the remainder of the system is pointed out and certain features of its design explained. The scheme of loading the machines and the method of load shifting between machines is given in detail. The distinctive features of the various types of machines at this station are discussed, particular attention being given to the control of the converter with transformer taps and high-voltage revolving field booster. The scheme of automatically changing taps under load is described fully. A brief summary of the protective features on this machine is also given.

The operating experience with the automatic equipment at the St. Charles St. Station is related.

Introduction

EDISON d-c. systems in large cities have been the result of natural growth and in many cases have reached such a size that their replacement would be a tremendous undertaking even though a careful study might indicate such a step to be desirable from an engineering standpoint. Since, to many companies, the operation of Edison systems is a big problem, it was felt that a description of the manner of revamping the Edison system in St. Louis and the results obtained would be of interest. In redesigning this system, the use of automatically controlled machines was thoroughly studied and tried out, and in this paper particular emphasis is laid upon the application of automatic control to the St. Charles Street Substation, Fig. 1, which is the largest Edison station and representative of the latest design of equipments.

The Edison System

The 250-volt Edison district of the Union Electric Light and Power Company covers an area approximately one mile wide by 1¾ mi. long, and at present attains a peak load of approximately 32,000 kw. The district is supplied from eight substations, all but two of which are entirely automatic.

The a-c. power supply to the stations is derived from two separate and distinct systems. Five of the stations are supplied at 60 cycles and three at 25 cycles, with approximately 50 per cent of the total capacity at each frequency, each system being fed by two plants; so that the Edison stations receive power at two frequencies and from two plants at each frequency.

No stand-by batteries are maintained on the 250-volt Edison system. Although this type of load demands a high degree of service continuity, it was felt that the improved reliability of the a-c. supply, together with the use of automatic control equipment for service restoration, made the batteries unnecessary. Motor-generator sets are relied upon for service restoration, all of them having stable operation at all voltages. The rotary converters are capable of operation through a considerable range of d-c. voltage, and all are a-c. starting.

Of the total system capacity, 36,600 kw., somewhat in excess of 50 per cent, is in motor-generators. This

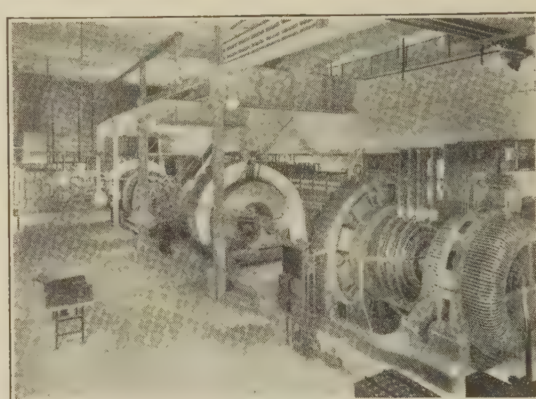

Fig. 1—General View of St. Charles St. Station Interior

means that in the event of a complete Edison system outage, the motor-generators will "come in" first and will be of sufficient capacity to raise the voltage to something above 50 per cent. At this point, the first converters will "come in" and further raise the voltage, being followed by the other converters as the system reaches their lower operating limit.

The system neutral is supplied by the rotary converters, the motor-generators in every case being two-wire machines. The converters are fairly well distributed over the system and a sufficient number is kept running during the night to properly maintain the neutral.

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The St. Charles Street Substation

The St. Charles Street Substation always has been the largest Edison station and being very close to the load center, it has always been considered a base load station. In 1925 everyone of the manual machines at St. Charles Street, with one exception, was reaching the end of its life and it was necessary that they be replaced. There was no question of whether the new machines should be manually or automatically controlled, for, aside from the apparent saving in operating expenses, the experience with automatic substations had demonstrated their ability to withstand system disturbances, their greater speed in service restoration and their superior voltage regulation.

Fig. 2 shows a one-line diagram of the station. It will be noted that power is received at 6600 volts 25 cycles, over five underground feeders, and is distributed over 32 outgoing low-voltage feeders.

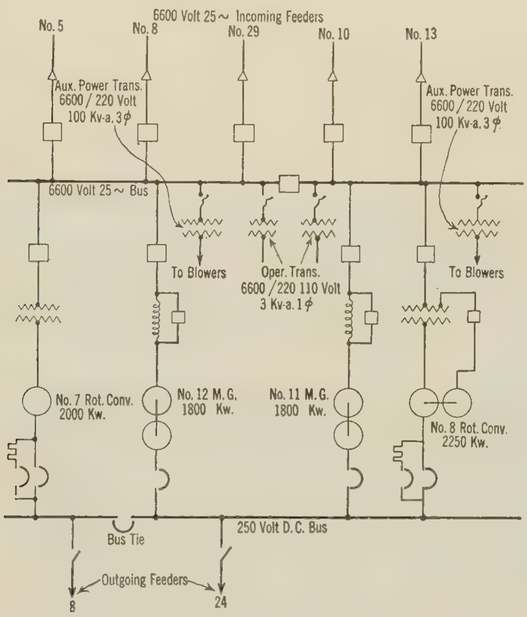

Fig. 2—One-Line Diagram of St. Charles St. Substation

The automatic control equipment for the station contains a number of features which are unique and new in the installation and for this reason, will be of particular interest. Some of these schemes of control were made necessary by the peculiar problems met in the design of this station, such as the use of a comparatively large number of automatically controlled machines, the use of a rotary converter with a new type of control for picking up the bus at low voltages, and the necessity for unusually close voltage regulation due to the heavy net-work and load in the area surrounding the station. Other features are new developments in the art and these will probably find further use in other installations.

The scheme of load division between machines of different characteristics operating in parallel, as employed at this station, was conceived and originally applied at the Eighth Street Substation by the company's operating engineers. The application in this case was simply an extension of the original scheme.

Starting, Stopping, and Loading Sequence

During normal light-load conditions, the tap-changing booster-type rotary converter, (machine No. 8), supplies the entire station load. The station voltage is controlled by the voltage regulating relay No. 58, which is governed by potential from a pressure wire bus, so that it tends to hold the net-work potential constant within its area. The bus voltage, therefore, varies in accordance with load conditions.

When the load on converter No. 8 reaches 95 per cent of full load, the load-responsive-starting relay, No. 1A, on No. 8 machine, operates through a time-delay starting relay, to bring onto the bus the second machine in the sequence, No. 12 motor-generator set.

When machine No. 12 closes its d-c. breakers, it takes the voltage control away from converter No. 8, and assumes load. The converter voltage is then controlled by its current regulating relays, No. 57. With no increase of station load, motor-generator No. 12 would pick up a relatively small load which would not be sufficient to keep it on the bus. To prevent this, its current limit recalibrating relay, No. 95, is arranged to decalibrate the current regulating relays on converter No. 8. This causes the rotary converter to reduce its load approximately 2000 amperes and this load, together with additional load which may come on, is picked up by motor-generator No. 12 until at 6300 amperes its current limit recalibrating relay picks up to again recalibrate the current regulating relays on converter No. 8. The converter then carries 100 per cent load, and motor-generator No. 12 continues to absorb the oncoming load until it reaches 95 per cent of full load.

At this point the load responsive starting relay No. 1A, on No. 12 motor-generator functions after a time delay to start the third machine in the sequence, No. 11. As soon as motor-generator No. 11 gets on the bus, it assumes control of station voltage and takes this control away from machine No. 12. Thus, rotary converter No. 8 and motor-generator No. 12 are being controlled by their respective current-regulating relays, and motor-generator No. 11 has its voltage controlled by voltage-regulating relay No. 58. To insure the No. 11 machine picking up enough load to stay on, its current limit recalibrating relay No. 95 functions to decalibrate the current regulating relay on No. 12 machine by approximately 2000 amperes. As the load builds up further, No. 12 machine is again permitted to assume full load, as limited by its current regulating relay.

When the load on No. 11 machine exceeds 95 per cent of full value, its load responsive starting relay No. 1A causes rotary converter No. 7, after the expiration of a short time delay, to be started. This machine

is not paralleled with the others in the station but instead feeds the network through a separate group of feeders on a section of the main bus. This section is automatically split off by the opening of the bus tie breakers when the converter is closed onto the bus.

With No. 7 converter on, voltage control is left with No. 11 machine as before and the voltage balancing relay No. 60 of converter No. 7 balances the voltage of its section of bus against that of the main bus, holding the voltage approximately two volts higher than the main bus. This results in converter No. 7 taking a little more than its share of the load and insures its having enough load to stay on.

With decreasing load, the machines are shut down in the reverse order from their coming on. Rotary converter No. 8 is not arranged with load-responsive starting and stopping, since it is required on the bus at all times to maintain the net-work voltage and the system neutral at this point.

Provision is made also for starting the next machine in the sequence if the last machine called for by the load is held off by protective devices or manual control switches. The next machine then does whatever the disabled machine would have done in the way of load shifting and voltage control.

In coming back on the bus after a system outage, it is not permissible to allow converter No. 8 to be connected to the bus below 140 volts, which is its lowest regulating point. In this case, the bus undervoltage relay, although permitting No. 8 machine to complete its starting sequence to the point where it is ready to be connected to the bus, functions to start both motor-generator sets as fast as power supply conditions permit. As soon as the motor-generators, together with other stations, have raised the bus voltage to 140 volts or more, rotary converter No. 8 is connected to the bus and boosts the system voltage to the limit of its ability. At approximately 210 volts, converter No. 7 will also be brought on the bus. This should raise the net-work voltage to approximately normal, provided the other units on the system have started properly.

Motor-Generators

Except for the load-responsive starting and voltage and load-regulating schemes described above, the control for both motor-generator sets is similar to installations previously described before the Institute. The synchronous motors are started by throwing onto the line through reactors, the reactors being shunted out when the machines have reached approximately synchronous speed. The field is applied at the time of transfer and upon equalizing the bus and machine voltages, load is applied to the d-c. generators. The sets are of the differential compound type, normally operated, with the series field shunted by an automatically controlled circuit breaker. The control is arranged and the sets are suitable for re-synchronizing under load, should power be temporarily interrupted.

Synchronous Converters

The booster-type synchronous converter, No. 7, is arranged for Y-delta starting by oil circuit breakers on the high-voltage side of the transformer. Correct polarity is established by temporary reversal of the field. This machine is connected to the bus through cushioning resistors, which are arranged to give two-step operation.

Synchronous converter No. 8 is a shunt-wound 2250-kw. three-wire machine with high-voltage revolving-field booster, the scheme of connections being as shown in Fig. 3. The converter has the customary series and shunt commutating fields. The booster is provided with a double armature winding so connected that with a given direction of excitation on the field, the voltage of one winding will be in the "boost," and the other in the "buck" direction. The winding used under any particular condition will depend upon the position of the tap switches. The high-voltage neutral is formed at the common point of the booster windings.

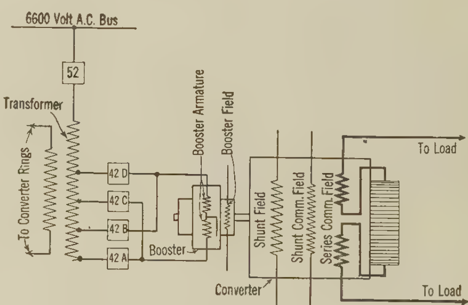

Fig. 3—Scheme of Connections of Windings, No. 8 Converter

The transformer is provided with an extended winding having four 10 per cent taps.

The control scheme used on converter No. 8 is, in many respects, new and novel, and for this reason, a rather full description will be given.

With the machine off, it will start upon closing of the master switch through the customary time delay, and the sequence will advance in about the same manner as for many standard converters. Approximately half voltage is applied to the converter rings for starting by closure of No. 42A tap switch. When full field is reached, full voltage is impressed on the converter by the opening of 42A and the closure of 42D tap switches.

The voltage of the converter is then equalized with the bus voltage by the operation of the booster field rheostat. When the voltages are properly equalized, the load limiting resistor breakers, No. 73, close. This is followed immediately by the closing of the line breakers, No. 72. Upon the closing of circuit breakers, No. 73, the control of the booster field rheostat, is given to the voltage and current regulating relays. These relays operate to hold the voltage of No. 8 machine

within $1\frac{1}{4}$ volts of normal value on the pressure wire bus until the converter is loaded to approximately 8700 amperes. At this point, the current regulating relays No. 57 take control and hold the current on this machine at an average value of 9000 amperes.

Tap Changing

When voltage reduction is necessary, the booster rheostat is run in the "buck" direction, and when maximum buck is reached a circuit is made to close tap switch No. 42C. It will be noted from the diagram, Fig. 3, that this connects the two ends of the booster across high-voltage taps on the transformer. As soon as No. 42C closes, No. 42D is opened and the converter is operating on the second transformer tap with the booster field rheostat in the maximum boost position. The transition from buck to boost is accomplished by the use of a double winding in the booster. When the tap change is made, the shunt field current is increased in correction for the change from generator to motor action on the converter. This action is simultaneous with the reversal of the auxiliary commutating field of the converter. This prevents "pumping" of the transfer equipment at the tap point.

If further voltage reduction is necessary, the booster rheostat moves out of the boost position and finally reaches approximately maximum buck. At this point, tap switch No. 42B is closed and No. 42C opened by a similar sequence to connect the converter to the next lower tap.

The necessity for further voltage reduction will orce the converter to the lowest tap by an operating sequence similar to that above which closes tap switch No. 42A and opens No. 42B. Demand for still lower voltage will force the booster rheostat into the maximum buck position and if this is not sufficient to reduce the fload on the converter to a proper value, the station d-c. undervoltage relay, No. 80A, will function to disconnect the machine from the bus. The converter will continue to run, in readiness to again assume load as soon as voltage conditions permit.

When the bus voltage rises above the setting of undervoltage relay, No. 80A, this relay will function to connect again the converter to the bus. The current regulating relays which have control until the bus voltage is normal, function to run the booster rheostat to the maximum boost position. At this point tap switch No. 42B will be closed and No. 42A opened. Simultaneously the auxiliary commutating field on the converter is reversed to again compensate the converter for the booster change, this time from boost to buck rather than from buck to boost which, it will be noted, is the reverse of the condition when "tapping down." Further decrease of converter load or increase of bus voltage will cause the tap changing equipment to "tap up" until the highest tap is reached, each tap change following the sequence outlined above. When the highest tap is reached, the converter is regulated to hold proper voltage or current in accordance with the indications of the voltage and current regulating relays.

Protective Features

The size and importance of this converter unit warrant extensive protective equipment and an endeavor has been made to protect against all operating contingencies, such as starting on single or reversed phase; starting with low a-c. voltage; incorrect brush position; incompleted starting sequence; failure of the converter shunt or booster field; d-c. reverse current; overheated bearings; overheated load limiting resistors; commutator flashover or grounded windings; overspeed; a-c. power failure; a-c. overload; incorrect polarity; overheated d-c. windings; excessive load unbalance; and overheated booster and transformer windings.

Conclusion

This equipment has now been operating fully automatic for somewhat over a year and its operation has been very successful.

There have been quite a few system disturbances with this equipment in service and in practically every case, the automatic control appeared to function correctly. In most cases, of course, there was no one at the station at the time of the trouble and the performance of the apparatus had to be determined from the chart records. However, during the disturbances when, by chance, men were at the station, many observations were made and a great deal of confidence gained. In one case, in particular, when the Keokuk transmission circuits were completely disabled by a tornado and the load thus released was suddenly thrown on the steam plants, this control gear operated admirably over a wide range of frequency and a-c. voltage and through severe d-c. load fluctuations until the system was again stabilized. At the time of the disastrous tornado of September 29th, 1927, none of the machines at St. Charles Street even dropped their load, although the a-c. system was subjected to many severe short circuits and grounds.

With improvements being made rapidly in automatic control apparatus, it is felt that increasingly complicated operations will be controlled automatically and still greater reliability obtained in the future.

The trend of electric truck construction is combining modern refinements with the sturdiness characteristic of electric truck manufacture since the beginning of the industry, according to a consensus of manufacturers.

With users of electric trucks built 15 to 20 years ago predicting still another 5 years service for such vehicles, the length of the life of the electric truck as it is built today cannot be estimated even by the manufacturers. In addition to being built for a long life of service, the modern electric is designed to suit the demand for such local delivery service as required by bakers, dairies, laundries, department stores, and other concerns having frequent stop delivery service. Its dependability, quick pick-up ability, and its inherent cleanliness make the electric particularly well suited for such service.

The Effect of Humidity on the Dry Flashover
Potential of Pin-Type Insulators

BY J. T. LITTLETON, JR.* and W. W. SHAVER*
Associate, A. I. E. E. Non-member

Synopsis.—*This paper shows that humidity affects considerably the flashover voltages of porcelain and PYREX insulators. The flashover potential rises as the humidity is increased. The tests were made on pin-type insulators and on rods. The results show that this rising characteristic is a surface effect which varies with the absolute water content of the surrounding atmosphere.*

INTRODUCTION

IT is probably generally recognized that the humidity or water content of the atmosphere has some effect on the flashover potential of insulators. The A. I. E. E. specifications for testing insulators[1] state that relative humidity measurements should be taken at the time of the test and recorded as part of the data. No correction factor for this condition has been worked out, however, and little seems to be known as to the quantitative effect of humidity changes. It seems to be a general belief that an increase in humidity leads to a decrease in flashover. Peek[2] has stated that humidity does not affect the flashover potential of sphere-gaps. Schwaiger[3] has given data on porcelain and glass rods in uniform tangential fields, showing a lowering of flashover potential with increase of humidity, and curves showing an increase in flashover potential on large insulators and constant flashover potential on small insulators with increase of humidity. Accordingly, it seemed worth while to determine the quantitative relationship between humidity and flashover potential on different types of insulators and insulators made of different materials, and, if possible, to work out a correction for this condition.

While the work on this problem has not been completed, inasmuch as no correction factor has been completed, it is believed that the measurements obtained are of sufficient value and interest to justify their presentation.

EXPERIMENTS

The electrical equipment consisted of a 150-kv-a., center-grounded, 60-cycle transformer with maximum voltage of 300 kv., controlled by an induction regulator. Flashover voltages were measured in either of two ways; (1) by a voltmeter previously calibrated with a sphere-gap, or (2), directly by the sphere-gap in parallel with the insulator with suitable high resistances on each side of the gap to prevent errors due to oscillations from the insulator under test.

The insulators were mounted and the tests conducted as nearly as possible according to the A. I. E. E. specifications for testing insulators.[4] The tests were made in a wooden box 6 ft. square and 5 ft. high with a hinged cover, all lined with waterproof paper. These dimensions gave less than the standard clearance for the insulator mounting so that in this respect the tests were not made according to the standard specifications. This condition did not noticeably affect the results, as measurements made in the box agreed with those taken in the room for comparison. The iron pipe holding the insulator pin ran diagonally through the box and projected through the walls so that the one lead was connected to it on the outside. The other lead to the half-inch brass rod tied in the line groove was insulated

FIG. 1—PYREX INSULATORS USED IN TESTS

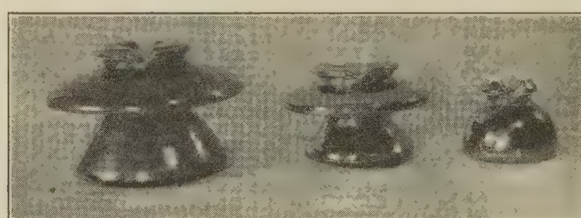

FIG. 2—PORCELAIN INSULATORS TESTED

from the chamber wall by a large bell shaped PYREX* insulator.

The humidity in the test chamber was controlled by the introduction of dry steam circulated throughout the box by a fan. Because of small leaks it was found necessary to introduce steam continuously in order to maintain a given humidity. Humidity measurements were made by means of a dry and wet bulb hygrometer suspended in the current of air from the fan, just inside a window through which the readings were taken. These results were converted to absolute humidity by means of the data given in the Psychrometric and Smithsonian tables.[5]

The experimental procedure was as follows; the insulator was mounted on the pin in the test chamber

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*Both with the Corning Glass Works, Corning, N. Y.

1 For all references see bibliography.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., Feb. 13-17, 1928.

*T. M. Reg., U. S. Pat. Off.

and a standard dry flashover test made with the natural humidity of the atmosphere. Steam was then introduced in the chamber and the humidity thereby increased and maintained at a constant value for 15 min. A second flashover test was then made and the cycle repeated. If it were desired to decrease the humidity

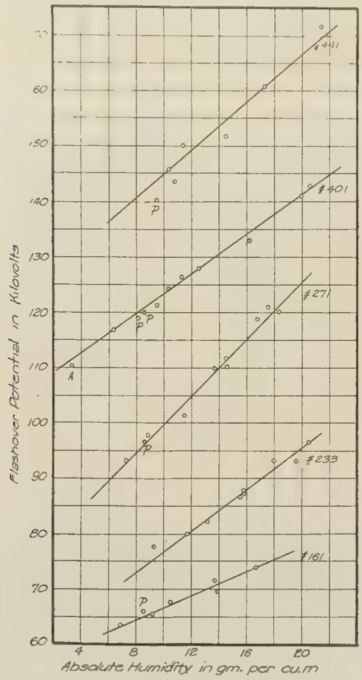

Fig. 3—Variation of Flashover Potential with Humidity, on PYREX Insulators

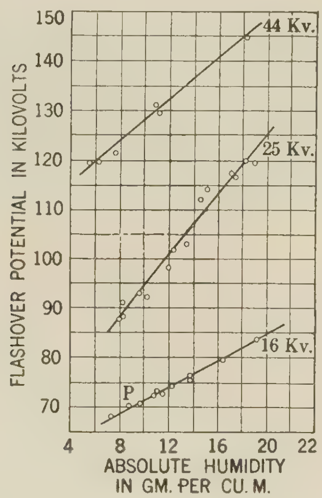

Fig. 4—Variation of Flashover Potential with Humidity, on Porcelain Insulators

after it had reached a point near saturation the cover of the box was raised and fresh air admitted. So far as possible, a given series of tests was made at a constant temperature, but on account of the steam used in the test, the temperature slowly increased, in an extreme case changing by as much as 4.5 deg. cent. However, temperature and pressure as well as relative humidity were recorded for each test and a correction applied to reduce the values to those for 25 deg. cent. and 760-mm. pressure.[6]

Measurements were made upon different types of PYREX pin-type insulators (see Fig. 1) and upon porcelain pin-type insulators, (Fig. 2), varying from 16- to 44-kv. rating. Tests were also made on the effect of humidity on the flashover potentials between No. 6 copper wire electrodes wrapped around PYREX rods of various diameters, and at various spacings. In addition, in order to determine whether or not the phenomenon was merely due to the humidity effect on the electrodes, measurements were made on the flashover potentials between a one-inch steel bar bent in the shape of a hook, and a loop of No. 8 copper wire, as well as between two loops of No. 6 copper wire.

Results

Figs. 3 and 4 show the results of a series of tests on

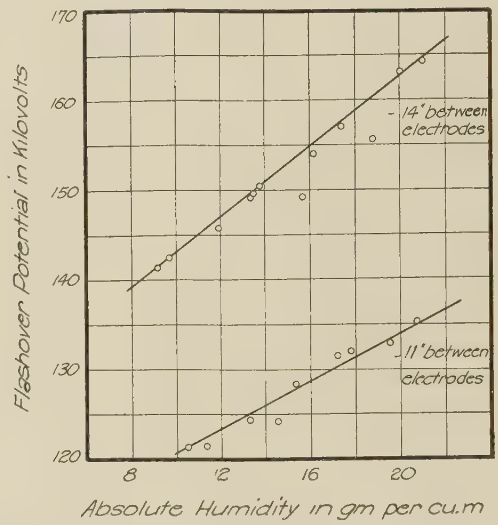

Fig. 5—Variation of Flashover Potential with Humidity, on PYREX Rod, 0.9 In. in Diameter

the different PYREX insulators and porcelain insulators, respectively. In every case there was a marked increase in the flashover potential when the humidity was increased. These curves do not show the maximum variations that have been observed, as considerably greater variations are possible when the experiments are made at a higher temperature, the maximum possible water vapor content in that case being much greater. In general it was found possible to increase the flashover potential of both PYREX insulators and porcelain insulators about 30 per cent over the value at a low humidity.

The results of some of the experiments on PYREX rods are shown graphically in Fig. 5 and again, increased humidity caused increased flashover potential. The results shown were obtained with a rod 0.9 in. in diameter and with the spacings between the electrodes as indicated on the graphs.

Fig. 6 shows the results of the measurements on the

flashover potentials between the loop of No. 8 copper wire and the one-inch steel rod bent in the form of a hook and between the two loops of No. 6 wire. In the first case, they were spaced so as to give a flashover potential about the same as that of a 44-kv. insulator; and in the case of the loops of No. 6 wire, the spacing was the same as when they were wrapped around a PYREX rod. From the slopes of these curves, it is quite evident that the humidity effect on the flashover potential of an insulator and of a PYREX rod cannot be attributed to any effect on the electrodes.

Discussion and Conclusions

As mentioned above, the curves show humidity values expressed in absolute units, since such units bring the measurements taken under different temperature and pressure conditions more nearly in agreement with each other than do those of relative humidity. Schwaiger[7] shows data plotted on a relative humidity basis which also come out as a straight line relation if temperature and pressure are kept constant, but in order to correlate data made at different temperatures,

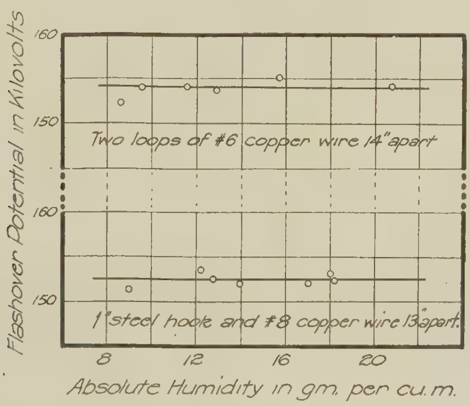

Fig. 6—Flashover Potential between Metal Wires and between Hook and Wire

Above, two loops of No. 6 copper wire, 14 in. apart.
Below, a 1-in. steel loop and a No. 8 copper wire, 13 in. apart

or to work out a correction factor, it is necessary to use absolute humidities. In addition he shows that in the neighborhood of 100 per cent relative humidity the flashover potential falls very rapidly, this effect beginning at even 80 per cent humidity on certain insulators. This decrease in flashover potential was noted in our experiments at humidities above 90 per cent, but it is believed that this was due to condensation on the insulator surface, which could be avoided by having the insulator at the proper temperature. Schwaiger's results indicate no humidity effect on flashover potential with an insulator of approximately the same dry flashover potential as the PYREX insulator No. 161 and the 16-kv. porcelain insulator. Our observations made on the latter insulators indicate a very definite effect and one which is also of considerable magnitude. Weicher[8] investigated the effect of humidity on the flashover potential between points and 2-cm. spheres so spaced as to give a flashover potential approximately the same as indicated in Fig. 6, and found that the flashover potential increased with increasing relative humidity. This does not agree with our observations on the flashover potentials between the two loops of copper wire and between the copper wire and the pin in which no humidity effect was observed.

The question as to whether the curves shown in Figs. 3 and 4, which were obtained under more or less artificial conditions, actually represent the phenomena when observed under standard conditions, is perhaps best answered by a reference to the point *A* on the curve in Fig. 3 for the 40-kv. PYREX insulator. This point was obtained from the average dry flashover values of five 40-kv. insulators of the same type as used in this test. The tests on the five insulators were made in the standard way outside the test box under low, absolute humidity conditions some months previous to the time when the other results shown were obtained. When correction is made for temperature and pressure, however, this value shows good agreement with the other results obtained in the special test box. As a further proof of this, the points marked *P* on the curves represent measurements taken under natural humidity conditions at Purdue University Electrical Engineering Laboratory.

It is not proposed to advance at this time any theoretical explanation of the results obtained, as the data at hand are not sufficient to warrant the development of any very definite theory. The results given on the accompanying graphs show that the effect is a surface one which varies with the absolute water content of the surrounding atmosphere. Since this is true, it is not surprising that the results are similar for both PYREX insulators and porcelain insulators, as in both cases the surface is of glass. It is perhaps worthy of note that the slopes for porcelain insulators are slightly steeper than those for PYREX insulators having approximately the same flashover potential. This may be accounted for by the high chemical resistivity surface of PYREX insulators.

Regardless of the cause of the phenomenon, experiments have shown that humidity has a marked effect on the dry flashover potentials of pin-type insulators. It is further apparent that the large change occasioned by humidity has a direct effect on the rating of an insulator. Extrapolation from the curve, together with temperature and pressure corrections, shows that a No. 441 PYREX insulator at 760-mm. pressure and 35 deg. cent. temperature would flash over at 128 kv. with a 10 per cent relative humidity and at 193 kv. with a 90 per cent relative humidity.

Moreover, the apparent straight line relation between flashover potential and absolute humidity makes it possible to adopt a correction factor for the humidity effect on a given insulator, and to catalogue the dry flashover potential at a standard humidity as well as at

a standard temperature and pressure. Until a satisfactory theoretical correction factor or formula has been determined so that humidity corrections can thereby be made it is believed that curves such as those given should be used as a measure of the standard dry flashover value of an insulator rather than a measurement at one known humidity.

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4. Loc. cit.

5. Psychrometric Tables by C. F. Marvin, U. S. Dept. of Agriculture. Smithsonian Tables, 1927 edition, p. 185.

6. Peek, loc. cit., page 111. The maximum possible correction as given by the formula $\frac{3.92 \times \text{Bar. pressure in cm.}}{\text{Absolute temperature}}$ was used in all cases.

7. Loc. cit.

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Welding and Manufacturing of Large Electrical Apparatus

BY A. P. WOOD[1]

Associate, A. I. E. E.

Synopsis.—The object of this paper is to show how extensively electric welding is being used in the fabrication of large electrical apparatus. It outlines the use and advantages of welding for supplanting the casting and machinery of parts and describes briefly the welding equipment developed for this purpose and some of the electrical machines produced by this method.

THE steps required in producing an electrical machine of iron or steel castings consist chiefly of engineering, drafting, making patterns and castings, machining, assembling, and finally, filling and painting.

The tendency of the present day, however, is to produce machines, particularly the larger electrical machinery, of welded steel plates. It is possible now by following the new modern process of fabricating a machine practically to eliminate the pattern shop as well as the foundry.

Welding passed beyond the experimental stage several years ago. Previously, it was principally used for repair work. Automatic welding equipment has recently been developed, which guarantees a much better weld, thus greatly reducing the possibility of personal error present in hand welding and insuring uniformity throughout the length of the weld. Considerable time and money is saved by resorting to automatic welding wherever possible, as it is more rapid than hand welding and there is no loss of welding wire as in the case in hand welding.

A drafting department can quickly produce simplified drawings calling for steel plates to be cut by flame, some of which are easily rolled circular, and then mostly automatically welded together, thus producing a stator or rotor.

By making these large structures of fabricated plates, no expensive patterns are required. Valuable pattern storage space, which had to be increased as time went by is thereby released and can be used for other manufacturing purposes. Foundry space is reduced and the substitution of welded forms for castings results in a great saving of time and eliminates the possibility of a defective casting due to cores shifting, blow holes, cold shots, and pouring gates, which require time to burn and machine off.

The work of the machine shop is reduced to a minimum, as the plates arc-welded together have approximately the finished dimensions, while in a casting there is of necessity a great amount of excess metal which is never twice alike and which requires excessive machining.

The first use of welding in a-c. machine construction was spot welding the armature-core air-duct spacers to the laminations instead of riveting them on. The next development was the adoption about 11 years ago of welded clamping flanges for holding the stator laminations. These flanges consist of sheared-off steel fingers arc-welded to steel retaining plates. About this time, arc-welded air deflectors made of sheet iron and angle iron were introduced.

In 1924, the General Electric Co. designed and built a 1400-kv-a. machine having the stator frame of welded steel plates. This stator consisted of two side plates having the supporting feet as part of the plate. The outside wrapper plate, foot plates, and ribs for retaining stator punchings, were then hand-welded in place. It was lighter than a similar cast machine, and deflec-

1. A-c. Engg. Dept., General Electric Co., Schenectady, N. Y.

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tion tests proved it to be much stronger. The chance of breakage due to handling while in the course of manufacture, or to short circuits after being installed, was greatly reduced. During the three intervening years, practically all stator frames of our machines have been changed over to this new form of construction.

When the steel plate frame is ready for painting it is of nice appearance, as any scale attached to the plates has been removed by sand blasting. No filler being required, the surface is quickly finished with a paint gun.

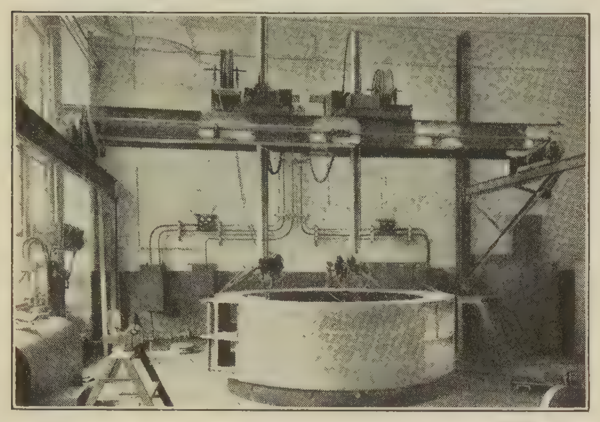

Fig. 1—Stator-Frame Automatic Welder for Frames up to 14 Ft. Diameter

These years of experience have justified the making of arc welded steel-plate machines as large as 40 ft. in diameter for slow speed, and as high as 10 ft. for high speed, and up to the present writing, of capacity up to 100,000 kv-a.

Fig. 2—Stator-Frame Automatic Welder for Frames Exceeding 14 Ft. Diameter

Very extensive tests have been made on samples of plates welded together with single-, double- and triple-layer welding,—both hand and automatic,—so that there is no question about the sort of welding to use for any particular design.

Wherever possible, on vertical or horizontal stators, rotors, bearing brackets, etc., hand welding has been superseded by automatic welding. On large diameter stators two or more circular plates made of segments, when in the same plane, are welded together by a semi-automatic hydrogen-enveloped arc. This results in a ductile weld that is easy to machine or grind and will not break if accidently stressed by being dropped in handling.

For general work, three principalt ypes of automatic welding machines have been developed. On the first type of welding machine, the welding heads are stationary and the piece to be welded is rotated past the heads. It is, however, only practical to rotate the work up to a certain diameter (see Fig. 1). With the second type of automatic welding, used for larger diameters, the radial arms of the automatic welding machine are made to rotate by a motor drive, Fig. 2. The third type of automatic welding is a straight-line welder in which the work is stationary and the welding head is moved.

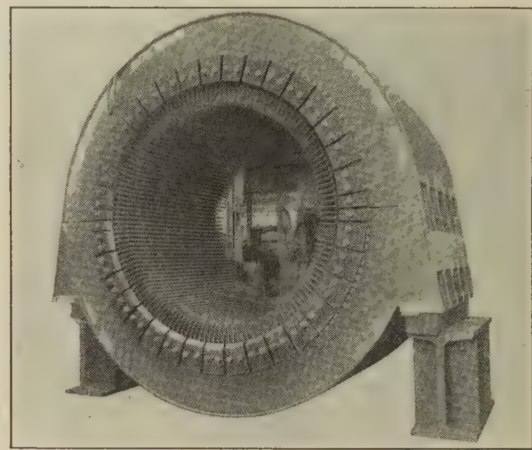

Fig. 3—Stator with Punchings for 50,000-Kv-a. Synchronous Condenser

The large automatic welding machines shown in Figs. 1 and 2 weld from 6 to 8 ft. per minute. The current used is between 300 and 400 amperes at 20 to 30 volts, depending on the gap between the pieces to be welded. Direct current is used.

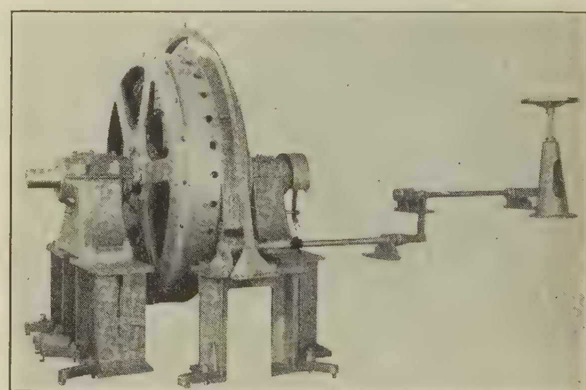

Fig. 4—A Welded Rotating Stator Frame for Super-synchronous Motor

The semi-automatic hydrogen-enveloped welding uses approximately 250 amperes at 40 to 60 volts, as it requires a higher voltage to maintain the arc.

The welding rod, or reel, on the automatic machines is of G. E. Type-B shielded wire, which consists of a steel core and outer steel layer between which is the flux. A high speed of welding is possible with this wire.

A large horizontal stator of 50,000 kv-a. is shown, Fig. 3. You will note the supporting feet are cut out as part of the side plates and welded to a heavy plate which is drilled for the holding down and adjusting bolts. The stator is split horizontally to aid in shipping, the two halves being held together by bolts and dowels inserted in the rectangular blocks, which were completed as a unit before welding in the stator. As a result of arc welding, we have produced large stator frames in 90 deg., 120 deg. and 180 deg., sections that require no setting up on expensive iron floors for machining or dowelling at the splits, as this operation is entirely eliminated. The ventilating air openings are located in the circular outer apron, or wrapper sheet, and are covered with punched metal covers. The laminations are mounted on the welded ribs and clamped tightly together by welded non-magnetic steel clamping flanges.

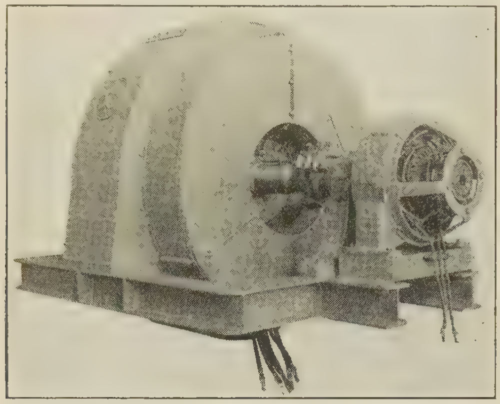

Fig. 5—Welded Beam Base for 2500-Kv-a. Synchronous Condenser

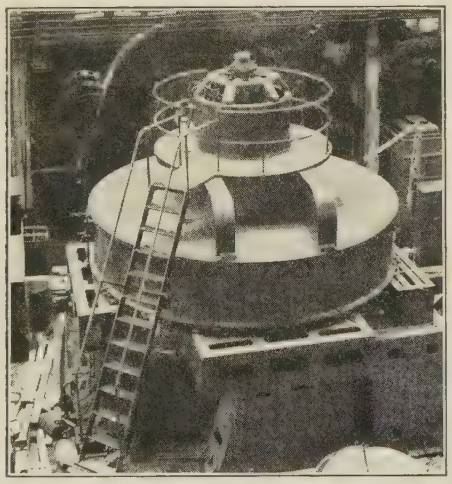

Fig. 6—Vertical Water-wheel Driven Generator Practically Entirely Welded

A rotating stator frame for a G. E. super-synchronous motor built up of arc welded rolled plates is shown in Fig. 4.

The next step in the elimination of castings on the horizontal machine was to replace the cast iron base with one of welded beams. (See Fig. 5). This design has been developed and built for machines up to 50,000 kv-a.

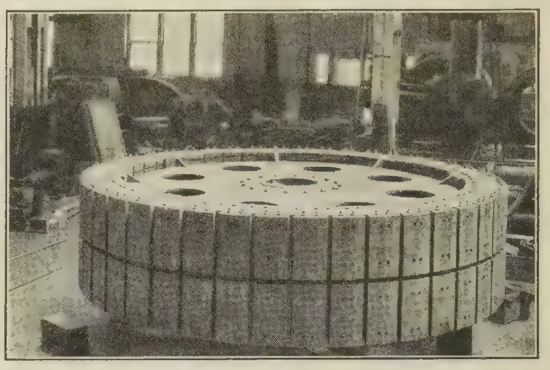

Fig. 7—Welded Rotor Spider for 19,700-Kv-a., Rev. per Min. Generator

Fig. 6 shows a medium sized vertical alternator, the mechanical parts of which are almost entirely of welded construction. The stator frame is similar in construction to the horizontal stator previously described, except that the bottom plate is of larger diameter, to permit of fastening to the foundation plates. A heavy rolled ring is welded to the top of the outside wrapper plate for supporting the top bearing bracket.

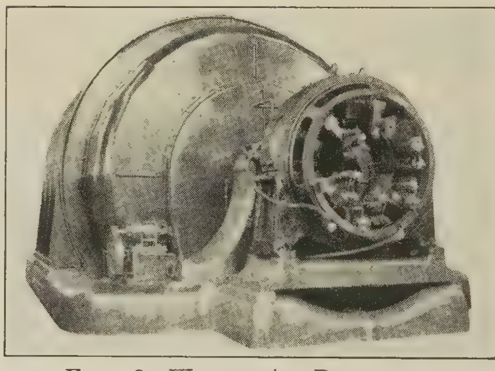

Fig. 8—Welded Air Deflector

A structural steel welded upper bearing bracket consisting of two rolled I-beam girders between which is bolted a welded housing carries the upper guide bearing and supports the thrust bearing which carries the weight of the rotor, waterwheel runner and thrust. The ends of these girders are cut off to a rather large radius and a steel plate is rolled to this radius and welded to the web of the beam. This construction does not appreciably affect the strength of the beam and gives the structure a more pleasing appearance. The platform around the exciter is made of plates, welded together, and the exciter, itself, has a frame made of a steel slab rolled to shape. Where the load on the upper bearing bracket is so large that rolled steel beams of sufficient size cannot be obtained, these brackets are made up by plates welded

together. We have recently finished two such fabricated beams similar in section to the rolled I-beam which are 30½ ft. long and 6 ft. high. The flanges and webs are welded together throughout their entire length. Between these beams is carried a welded thrust bearing housing designed to support a load of 350 tons.

A large number of cast rotor spiders have been replaced by various designs of welded plate construction. On the smaller spiders the hub is cut from thick steel plate or made from casting stock, to which is welded a center web-cut out of heavy rolled plate. The rotor rim is steel plate rolled to the proper diameter and welded to the center web. This outside rim may be either a single plate with a butt welded joint or made of two rolled plates having the joints staggered and welded together completely around the outer edges. Since the rim plate is welded to both sides of the web plate around the complete periphery, the welded joint of the rim does not have to take the entire load of the centrifugal force of the poles.

For the larger class of rotors a welded-plate spider is used to support a rim built up of thin laminations. Such a design for a 19,700-kv-a. generator is shown in Fig. 7. The center spider consists of circular plates for the top and bottom members which are welded to a center hub. Plates are spaced around the outer periphery of the plates which serve as a backing support for the rim laminations and are slotted for keys which transmit the torque from the shaft to the rim. Bolted to the bottom circular plate are segments of heavy plate which act as a braking surface and in addition support the weight of the rim. This type of design has been quite generally adopted as standard for the larger slow-speed vertical generators.

Welded structural-steel bearing brackets for supporting the lower guide bearing have been standard on large diameter vertical machines since about 1922. Ordinarily, these brackets are built of rolled shapes fabricated by flame cutting and welding. Mounted on the lower bracket are combined brakes and jacks which are also fabricated of parts welded together.

The original cast iron enclosing shields for positive ventilation on horizontal machines have been replaced by a combination welded and riveted sheet iron shield. Fig. 8. clearly shows the method of obtaining a large radius to the shields which is pleasing to the eye and seems so necessary when castings were used. An open-type spot-welded shield has been standard for a good many years.

The development of the art of welding and flame cutting has marked a new era in the design of electrical machines, particularly those which are either very large or special. The advantages of obtaining a structure which is homogeneous, free from possible casting defects, long and costly machining, and which lends itself so admirably to changes in design without any more expense than the change of a drawing, are, in the writer's opinion, so great that they cannot be ignored.

INCREASED USE OF ELECTRICITY IN SWEDEN

The use of electric current in different industries and for household purposes is constantly increasing in Sweden. Extensions have already been made at some of the power stations, and preparations are being made according to *Commerce Reports* for further extensions to meet the increased demand.

The power station at Porjus in the far north of Sweden supplies the current for the iron-ore mining, the electric railway line, generally called the "Ore Line," from Lulea on the Baltic to the Norwegian port of Narvik, and also, recently, for the households in the city of Kiruna. Increased mining activity has necessitated extensions at this station, and a new 10,000-kilowatt generating unit (the seventh at Porjus) is at present being installed.

It is important that the Baltic coast north of Stockholm, with its extensive lumber and pulp industry, obtain cheap electricity, partly for the benefit of the existing plants and partly to make extensions possible in order to lessen the unemployment. There are a number of power stations in this district, the largest of which, the Norrfors station, produces 100,000,000 kw-hr. per year, and others are under construction; current is also obtained from the Porjus power station, but the supply available from this source is limited. It has, therefore, been proposed in the Riksdag that a high-voltage cable of 70,000 volts be constructed from Porjus.

The power stations at Trollhattan, Alvkarleby, Motala, and Vasteras, generally called the Central Block, supply the current for central and southern Sweden, including the electric railroad between Stockholm and Goteborg. The total output of electric current by the Central Block during 1927 was estimated at 1,240,000,000 kilowatt-hours, but consumption is steadily increasing, and different ways of meeting the increased demand are being considered. Investigations are being made of the possibilities of regulating the flow of water from Lake Vattern past Motala and from Lake Vanern past Trollhattan.

A regulation of the Dal River (Dalalven), which supplies the hydraulic power at Alvkarleo, is being carried out and when completed will be of advantage to the power station.

The waterpower administration has requested a government appropriation of 2,000,000 crowns for the budget year 1928-29, and it is stated that the major part of this fund will be used for an extension of the steam electric plant at Vasteras, which acts as a reserve and peak station for the entire government power system in central and southern Sweden.

Attempts are also being made to arrive at a system of cooperation between the government stations and the private ones, and the waterpower administration is at present negotiating for this purpose with the Lanforsen power station, the capital stock of which is controlled by the city of Stockholm.

Saturation Permeameter

BY S. L. GOKHALE[1]

Member, A. I. E. E.

Synopsis.—*The saturation permeameter is a device for speedy and accurate measurement of saturation value of magnetic material; that is, for measurement of the limiting value of intrinsic induction (β) characteristic of that material. The permeameter in its present form is of the well-known bar-yoke type, with a magnetizing coil capable of producing a magnetizing force of H = 4500 g. without excessive heating. The permeameter is equipped with a compensating coil whose function is to compensate automatically for the spatial flux enclosed by the potential coil, so that the ballistic deflections indicate the saturation value without further computation or correction. The permeameter is available for accurate measurement of saturation value of such material as is saturated well within the working range of the permeameter, i. e., with a magnetizing force of H = 3000 g., or less, which includes all magnetic material used for electrical engineering purposes except those for permanent magnets and cobalt. The saturation permeameter is also available for approximately correct measurement of B or β, for range of H below the saturation point as far down as H = 200 g. In speed of testing and accuracy of the measured saturation value, this permeameter surpasses all devices for saturation measurement developed heretofore.*

THE following symbols are used in this paper with the corresponding unit stated in brackets:

B Total induction or flux density (gauss).
β Intrinsic induction ($B - H$) (gauss).
H Magnetizing force (gilbert per cm.; briefly g.).
H Spatial induction (gauss).
λ Interlinkage (Maxwell).

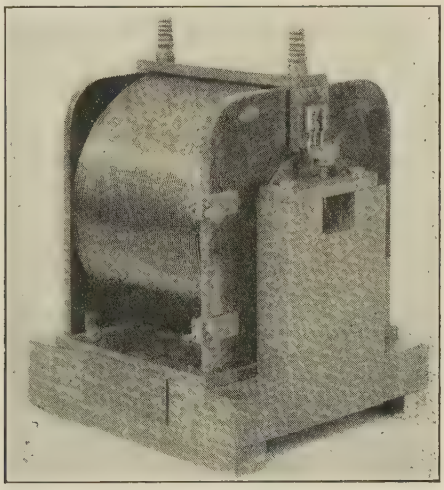

FIG. 1—SATURATION PERMEAMETER

I Magnetizing current (ampere).
S Saturation value; *i. e.*, limiting value of β.
A Cross-section of space enclosed by potential coil.
a Cross-section of material under magnetic test.
n Number of turns of potential coil.
M_c mutual inductance of the compensating inductor.
H/I H-factor of the permeameter.
H_s Saturation point; *i. e.*, the value of H at which β reaches the constant value S.
μ_i Intrinsic permeability, $(B - H)/H$, or $\mu - 1$.

The symbol H is ambiguous, but the ambiguity causes no inconvenience and is therefore left uncorrected.

1. General Engineering Lab., General Electric Co., Schenectady, N. Y.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928.

METHOD OF TEST

For scheme of wiring see Fig. 2. The compensating inductor which is a variable mutual inductor M_c is adjusted to the required value approximately to start with, and exactly by trial as the test progresses. The permeameter is then treated like the ordinary bar-yoke permeameter, using magnetizing currents ranging from 5 to 30 amperes. If the upper part of the magnetization curve thus obtained appears to be straight over a considerable range, after making a reasonable allowance for stray points, it is assumed that the sample is really saturated for that range. The compensator is then adjusted by trial until the deflection for the supposed saturation range appears to be strictly constant. The constant value of β thus indicated is accepted as the true saturation value. The lower part of the magnetization curve is theoretically not reliable, but it has been observed that for magnetizing forces as low as H = 200 g., the βH curve by the saturation permeameter is in very close agreement with the corresponding part of that curve by the Bureau of Standards compensation method (Fig. 3). This value of magnetizing force (H = 200 g.) is therefore accepted as the lower limit of reliability of the saturation

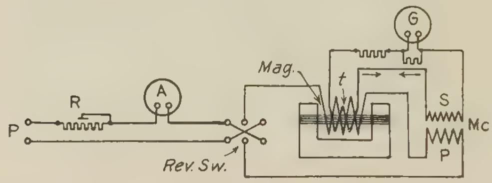

FIG. 2—WIRING DIAGRAM FOR DETERMINATION OF SATURATION

This illustrates the compensation method. It is also the connection used in testing the range of reliability of the instrument

P =Source of power, direct current
R =Control rheostat
A =Ammeter
Mag. =Magnetizing coil of saturation permeameter
t =Potential coil for measurement of β
H' =Coil for measurement of H' located in the space between the test sample and the inner surface of the magnetizing coil (not shown in this diagram; used for test in paragraph 5, Fig. 4)
M c =Mutual inductor—variable for compensation
P—Primary coil
S—Secondary coil
G =Galvanometer

permeameter, although in some cases the agreement may reach down to lower magnetizing forces (Fig. 6).

DETERMINATION OF H-FACTOR

The function of the compensating inductor is to compensate for the spatial flux enclosed by the potential coil of the permeameter. When the compensation is exact, as shown by the constancy of the indicated value of β, the interlinkage of the secondary coil of the inductor must be equal to the spatial interlinkage of the permeameter. Expressed analytically, we have the equation

$$\lambda s = \lambda c$$

or,

$$H\,n\,A = M_c\,I/10$$

where λ_s is the spatial interlinkage of the potential coil of the permeameter,

λ_c is the interlinkage of the secondary coil of the compensator.

Then, the H-factor of the permeameter is

$$H/I = M_c/10\,n\,A$$

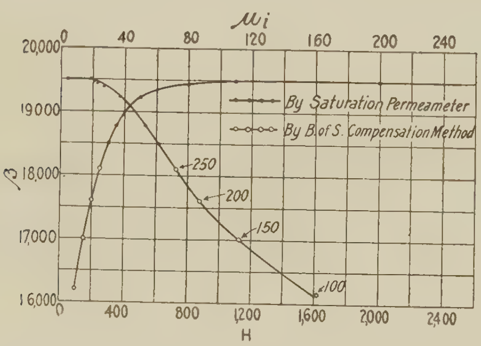

FIG. 3—CURVES OF 2½ PER CENT SILICON-STEEL SHEET

Tests on sample No. D-7. $\beta\,H$ curve and $\beta\,\mu_i$ curve are shown. The numbers on the $\beta\,\mu$ curve indicate values of H

CONDITIONS OF RELIABILITY; BASIC ASSUMPTIONS

When the compensation is exact, as indicated by the constancy of the observed ballistic deflection, the interlinkage under measurement is constant; hence we have the equation

$$\beta\,n\,a + H\,n\,A - M\,I/10 = \lambda_s = \text{constant}$$

where λ_s is the value of the total interlinkage measured,
$\beta\,n\,a$, interlinkage of intrinsic flux,
$H\,n\,A$, interlinkage of spatial flux,
$M\,I/10$, interlinkage of compensating inductor.

By differentiation with relation to I, we get

$$n\,a\,.\,\frac{d\,\beta}{d\,H}\cdot\frac{d\,H}{d\,I} + n\,A\,.\,\frac{d\,H}{d\,I} - M/10 = 0.$$

$$d\,\beta/d\,H = (M/10 - n\,A\,.\,d\,H/d\,I)/(n\,a\,.\,d\,H/d\,I)$$

Assumption I. Assuming that the H-factor of the permeameter is constant for the range under consideration, we have the equation

$$H/I = C$$
$$d\,H/d\,I = C$$

Substituting this value in the above equation, we get

$$d\,\beta/d\,H = (M/10 - n\,A\,C)/n\,a\,C$$
$$= \text{constant}$$

Assumption II. At this point, a further assumption is made, *viz.*, that if $d\,\beta/d\,H$ is constant, the value of the constant is zero. Graphically, it is assumed, that if any extensive part of the $\beta\,H$ curve be straight, it is at the same time also parallel to the axis of H. In other words, it is assumed that no large part of the $\beta\,H$ curve is straight without being parallel to the axis of H. With this assumption, the above equation is reduced to the two equations,

$$d\,\beta/d\,H = 0;\text{ and } n\,A\,C = M/10.$$

From the first equation we get

$$\beta = \text{constant}$$
$$= S;\ \text{(saturation value)}$$

From the second equation we get

$$H\text{-factor} = C = M/10\,n\,A$$

The reliability of these two measurements depends upon the validity of the assumptions (1) constancy of the H-factor for the required test range; and (2) absence of straightness of the $\beta\,H$ curve except when saturation is reached.

The constancy of the interlinkage by itself does not carry with it unconditionally the assurance of saturation, or the accuracy of the measurement of S, or of the H-factor. The equation

$$d\,\beta/d\,H = (M/10 - n\,A\,.\,d\,H/d\,I)/(n\,a\,.\,d\,H/d\,I)$$

might hold true when neither $d\,H/d\,I$ nor $d\,\beta/d\,H$ are constant, because it may be that the variations in β due to changes in H might be balanced by changes in H due to variations of H-factor. It can be shown, however, that in the case of the saturation permeameter under discussion, the constancy of the observed deflection is not brought about by balanced variations of this kind. Space limitations prevent the discussion of the proof of this point.

Validity of Assumption I. There has been no method discovered for direct measurement of H at a point in the test sample, and not even for indirect measurement, except under certain favorable conditions which are not present in this case. But the value of H at a point inside of the magnetizing coil and in close proximity to the sample can be easily measured by ballistic determination of spatial flux near that point. (For test data see Fig. 4.) A study of the curves shows that the H-factor for the proximate space is practically constant, the deviation from constancy ($\Delta\,\theta/\theta$) being undetectable for $I = 5$ to 20 amperes and less than one part in 1000 for the range $I = 3$ to 29 amperes. On the basis of this observation it seems reasonable to assume that the H-factor in the body of the sample is also constant within the same limits, because the causes that tend to produce deviation in the one case are also the only possible causes operative

in the other case. It is therefore assumed that in the case of this saturation permeameter, the H-factor is strictly constant for values of I between the limits 5 to 20 amperes (H = 750 to 3000 g.) and almost constant for I = 3 to 29 amperes (H = 500 to 4000 g.).

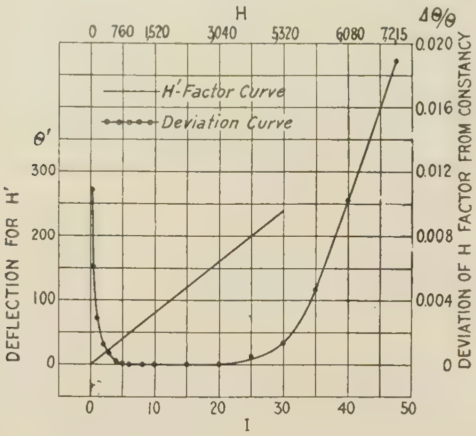

FIG. 4—H-FACTOR CURVE AND PRECISION LIMITS

Validity of Assumption II. The second assumption underlying the compensation method is, that no part of the βH curve is straight without being parallel to the axis of H at the same time. Stated analytically the assumption is that $d\beta/dH$ is not constant but varies with H, except when it (*i. e.*, $d\beta/dH$) becomes zero. The assumption is supported by numerous tests on magnetic material of various kinds, tested in the form of toroid rings to preclude uncertainty due to possibilities of error inherent in other methods of test. It was found in all these cases that the βH curve was not straight until the saturation point was reached, after

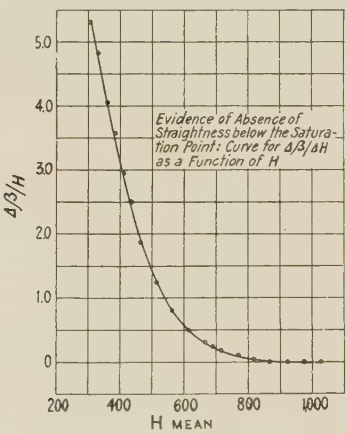

FIG. 5—CURVATURE OF βH CURVE BELOW SATURATION

The curve is for $\Delta\beta/\Delta H$ as a function of H. Standard sheet-steel toroid rings used with compensation for spatial flux

which point the curve was straight and parallel to the axis of H. In no case was a large part of the curve straight without being parallel to the axis of H.[2] In order to submit the matter to a more severe test, one toroid ring was tested by the differential test. (See Fig. 5). In this case the value of $\Delta\beta/\Delta H$ is not constant until it is reduced to zero. All reliable data thus far are in support of the Assumption II, and there are none to contradict it.

Examples of apparent exceptions are given in paragraph on Form of intrinsic permeability curve (See Incidental Observations).

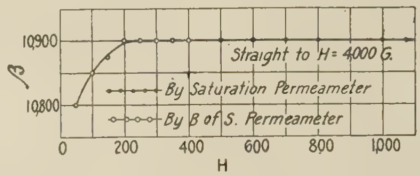

FIG. 6—βH CURVES FOR PERMALLOY ROD

Experimental Evidence of Reliability. Fig. 6 represents the βH curve for a sample of permalloy by the saturation permeameter, this sample being selected for the reason that it can be saturated by a magnetizing force of H = 200 g., which permits its saturation value to be determined by the Bureau of Standards compensation method, whose reliability has been accepted as indisputable. The close agreement of the two βH curves by the two methods constitutes a very persuasive argument as to the reliability of the saturation permeameter. This experiment disproves the balanced compensation referred to in paragraph on Conditions of Reliability and confirms the validity of the two basic assumptions. Full discussion cannot be given in this paper.

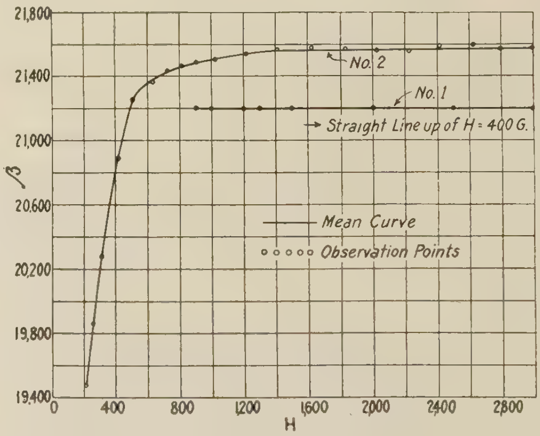

FIG. 7—SATURATION OF PURE IRON

Curve 1 was taken by the saturation permeameter; curve 2, by the Bureau of Standards isthmus permeameter. Curve 1 shows the absence of stray points by the saturation test

Internal Compensation. For further simplification of test procedure a small coil of sufficient interlinkage-coefficient, located in the proximate space, may be used in place of the compensating inductor. This method of compensation has the advantage of simplifying the test procedure, as the adjustment is made once for all and needs no further consideration.

2. Gokhale, Sept. 1926, p. 853, et. seq.

Incidental Observations

Absence of Stray Points. The saturation part of the βH curve by the method outlined herein is free of stray points. This is due to the fact that the ballistic deflections for this part are not dependent on the exact

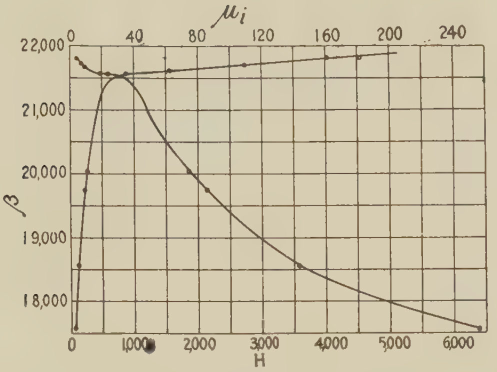

Fig. 8-1—$\beta\,\mu$ Curve by the Long-Solenoid Method

This is the method of B. O. Peirce, Academy of Arts and Science, (Vol. 49-2, p. 139, Table 6)

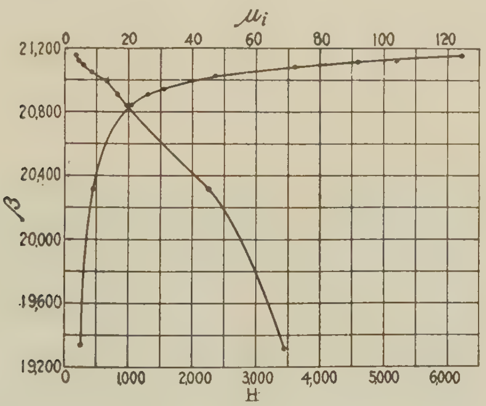

Fig. 8-2—$\beta\,\mu$ Curve by Yoke Isthmus Method

By Gumlich, *Arch. f. Elec.*, Vol. II, p. 471

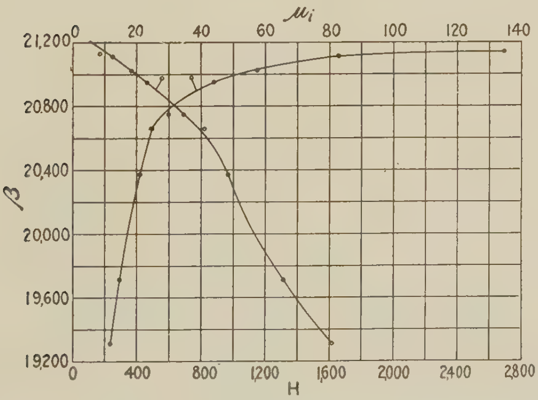

Fig. 8-3—$\beta\,\mu$ Curve by Bureau of Standards Isthmus Permeameter

By Cheney, Bureau of Standards. Paper No. 361, p. 633

value of the magnetizing current; any error in reading the ammeter has therefore no effect on the deflection; all the observation points for this part of the curve fall on a straight line parallel to the axis of H. In this respect this method of test surpasses all other methods. (For comparison, see Fig. 7).

Speed of Test. Since the accuracy of measurement of S does not depend on the accuracy of the ammeter, it is needless to waste time in accurate adjustment or reading of the current. The only reason for reading the ammeter at all is to assure that the observation points which should be sufficient in number and reasonably well distributed are actually so: the operator is instructed to waste no time and effort over accuracy of reading of the ammeter; this contributes to speed of test.

Freedom from Excessive Heating. The rapidity of test prevents excessive heating and thereby adds to the accuracy of the test. It is well known that variation of temperature constitutes one serious source of error in measurement of saturation value.

Form of Intrinsic Permeability Curve. The form of the $\beta\,\mu_i$ curve obtained by the saturation permeameter (Fig. 3) possesses all the characteristic peculiarities of the curve, by the compensated toroid ring method described in the *Law of Magnetization.*[3] The corre-

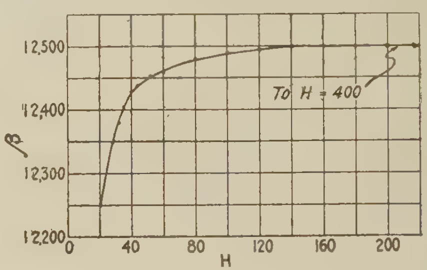

Fig. 9—Saturation of Nickel-Iron Alloy Ring By Incremental Method

sponding curves by other methods of test do not generally possess that form which indicates the unreliability of those methods (see Fig. 8). In such cases only, the βH curve is straight over a considerable range, without being at the same time parallel to the axis of H. These curves constitute the apparent exceptions to the *Assumption* II referred to in *validity of Assumption* **I.**

Demonstration of Saturation. Incidentally, we have now an experimental evidence of the phenomenon of saturation by a large number of tests on toroid rings, and therefore free from any uncertainty inherent in any type of permeameter whose reliability is unproved. In one case (see Fig. 9), the ring was tested by the method of increment which reduces the limit of observation error to ± 2.5 gausses in β. In this case the variation of the curve from straightness—if there be any variation at all—does not exceed one part in 5000. This experiment therefore constitutes a convincing evidence of the phenomenon of saturation, and therefore also a confirmation of Weber's theory of molecular orientation.

Limits to the Use of Saturation Permeameter. The theory of the saturation permeameter implies two

3. A. I. E. E., Trans. 1926, Vol. 45, p. 1023 and Disc. p. 1033, Figs. 4-0, 6-0.

limitations to its use. Firstly, the test sample must be capable of saturation well within the upper precision limit of the permeameter, *viz.*, $H = 4000$ g. (See Fig. 4.) For practical reasons $H = 3000$ is regarded as the upper limit. Magnetic material which does not reach saturation at this point, such as cobalt, cannot be successfully tested by this permeameter, for determination of saturation value. Secondly, the saturation permeameter is not theoretically available for accurate test much below the lower precision limit, (*viz.*, $H = 750$ g. See Fig. 4). But it has been observed in all cases that the curves obtained by this permeameter agree very closely with corresponding curves by the Bureau of Standards method, down to $H = 200$ g. (See Figs. 3 and 6.) This value of H is therefore considered as the lower limit of practical reliability.

Conclusion

From the preceding arguments, data, and curves, it follows that the saturation permeameter is speedier and more reliable than all other types of apparatus used until now for determination of saturation value.

Abridgment of

Synchronous Machines—IV

BY R. E. DOHERTY* and C. A. NICKLE*
Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*The special case of cylindrical rotor machine has been treated previously by Boucherot and others. The present paper solves the general case, including salient pole machines. The cylindrical rotor type thus becomes merely a limiting case. The principle assumption which distinguishes the present theory from the extensively studied cylindrical rotor theory is that the total armature self-inductance is here taken as variable with respect to rotor position, whereas the previous theory of short circuits, as represented by Boucherot, for instance, assumes this inductance to be constant—in other words that the air-gap is uniform.*

Expressions are derived for the short-circuit currents in the armature and field, for voltage induced in the open phase, and for voltages across external reactances in the armature and field circuits. Comparison of calculated and test curves for these quantities are shown in Figs. 5 to 8, for a 7000-kv-a., 385-rev. per min., salient pole alternator, and in Figs. 11 to 25 for a 20-hp., 1800-rev. per min. induction machine (cylindrical rotor). These show satisfactory agreement.

The mathematical work and definitions are in Appendixes as follows: A. Summary of Equations. B. Armature Current. C. Field Current. D. Voltage Across External Reactance in Armature Circuit. E. Voltage Across the Open Phase. F. Voltage Across the Open Phase. G. Variation of Armature Inductance with Position. H. Decrement Factors. I. Reactances—Definitions and Relations.

Historical

At the Annual Convention in June 1926 the authors presented the first of a series of papers covering their investigations of the Synchronous Machines. Part I was an extension of fundamental theory; Part II, a treatment of torque-angle characteristics under steady state conditions; and Part III, presented at the 1927 Winter Convention, a study of torque-angle characteristics under transient conditions. In the present paper, an analysis is made of single-phase short circuits.

Certain special cases of short circuits have been treated previously. Following the early work by Steinmetz[1] and Berg, Boucherot[2] presented his classical paper in 1912, dealing with alternators of the laminated, cylindrical rotor type, with and without amortisseur winding. In 1915 Diamant[4] reviewed the work of Berg and Boucherot, and, among other mathematical extensions, gave expressions for the envelope of the short circuit current. In 1918 he presented an analysis of sustained short circuits, dealing principally with the nature of flux distribution under that condition. In the same year,[9a] one of the authors proposed the use of the *Constant Linkage Theorem* in dealing with short circuits, and in 1921[9b] and 1923[9e] illustrated its use. Also in 1923 Franklin[5] applied this method to a large number of cases of single-phase and three-phase short circuits. Working from the same fundamental premises, Laffoon[7] solved additional cases in 1924. The following year Karapetoff[6] analyzed, in the main, the same cases as those of Franklin and Laffoon; but he started from a somewhat different theoretical basis—*i. e.*, from Kirchoff's Laws. But he, like Franklin and Laffoon, neglected resistance, which made the fundamental premises the same—since the Constant Linkage Theorem is merely a corollary of Kirchoff's Second Law, for the special case of negligible resistance. That is, his equations involved voltages instead of magnetic linkages, and were therefore the first derivatives of the corresponding equations in Franklin's work. Involving the same assumptions regarding the circuits, the results naturally also agreed. The thorough, mathematical treatments of cylindrical rotor machines both by Shimidzu and Ito[8] and by Biermanns,[3] in which the effect of resistance is approximately taken into account, are especially noteworthy. All of the foregoing investigations have dealt with cylindrical rotor machines;

*Both of the General Electric Company.

1. For all references see bibliography in complete paper.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

and, granting the simplifying assumptions which have appeared to be practically necessary,—such as those made by Shimidzu and Ito, and Biermanns, relating to resistance and saturation—it may be said that a practical solution of short circuits for the cylindrical rotor type has been attained.†

Scope

These previous analyses, however, have not solved the important case of salient pole machines. The present paper treats of the general case, including both types. Proceeding from the same basic point of view from which the authors' previous work on Synchronous Machines,[9d,9e] has been developed, the present treatment takes up single-phase short circuits and partial short circuits—*i. e.*, with external reactance in the armature and field circuits—, developing expressions

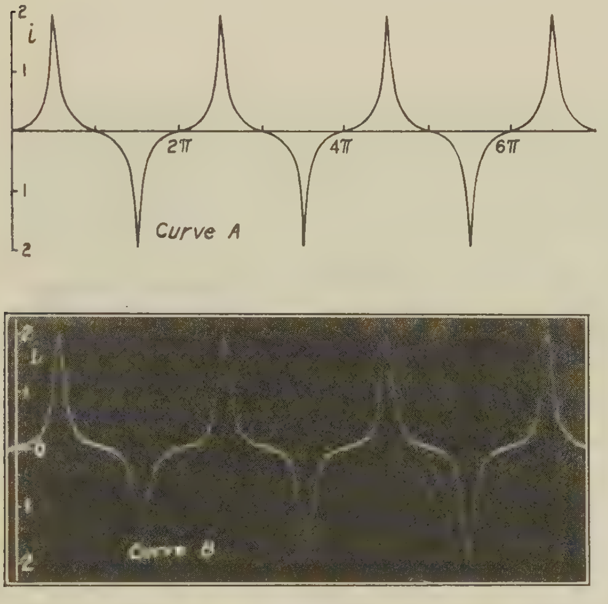

Fig. 13—Sustained Armature Current on Single-Phase Line-to-Line Short-Circuit 20-Hp. Machine

A—Calculated curve
B—Test curve

Equation:— $i = \dfrac{0.818 \sin t}{3.98 + 3.56 \cos 2t}$

for armature current, field current, armature voltage across the open phases, voltage across reactance in the armature circuit, and the voltage across reactance in the field circuit. These expressions apply not only to salient pole machines, but also to the cylindrical rotor type, since, under the present theory, the latter type merely becomes a special case of the former. Thus, the scope includes the development of expressions, applicable alike to salient poles and cylindrical rotors, for the voltage and current phenomena under single-phase short circuit.

†After submitting the present manuscript, a copy of S. Bekku's treatment of "Sudden Short-Circuit of Alternator," Bibliography 12, has been received. This treats of the case of the cylindrical rotor machine with a three-phase winding on the rotor, each rotor circuit being closed either directly or through the exciter. He employs "Heaviside" in the mathematical work.

Although the single-phase phenomena of *three-phase* machines only are considered here, the theory is, of course, applicable also to two-phase machines.

Discussion of Theory

The four basic concepts underlying the improvement in theory, both as applied here and in the authors' previous work, are: (1) characterization of the machine

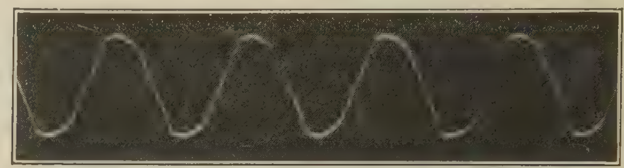

Fig. 14—Sustained Armature Current, Single-Phase Line-to-Line Short Circuit with $x_D' = x_Q'$ 20-Hp. Machine

by four reactance coefficients, two corresponding to the main pole axis—*i. e., direct axis*—, and two to the interpolar axis—*i. e., quadrature axis.* These are; x_D, x_D', x_Q, x_Q' (See Notation). Thus more or less aptly the theory has been referred to as the "Four Constant Theory."

2. Resolution of flux and m. m. f. waves traveling with respect to the rotor into stationary, pulsating components in line with the *direct* and *quadrature* axes. The theory involves also, of course, the usual Blondel resolution of the *stationary* fundamental waves.

3. That the variable component of armature inductance varies between the *direct* axis value and the *quadrature* axis value as a second harmonic function of the electrical space angle. This applies to all variable components of inductance which, with armature current of fundamental frequency, produce fundamental voltage.

4. The complete use of a fractional system of notation, thus expressing each quantity as a *decimal* fraction of some definite, convenient value, such as "normal" value. This is, of course, an outgrowth of the familiar

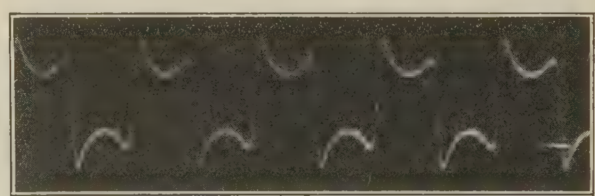

Fig. 15—Sustained Armature Current Single-phase Line-to-Line Short Circuit with $x_D' > x_Q$ 20-Hp. Machine

practise of expressing such quantities as a per cent of normal value, but the latter involves carrying along the "100" in calculations, which is both cumbersome and conducive to numerical error. Experience has established a very definite preference for the former—the only difference between them, of course, being the position of the decimal point. Thus with *unity* as the base, instead of "100", it is proposed to denote the

former by "per-unit" system, instead of "percentage" system.

The use of the "per-unit" system has distinct advantages. In the first place, the results are in forms which have a definite significance in giving at once an idea of relative values—for instance, a current of 0.5 means 50 per cent of normal current. Another advantage is that cumbersome conversion factors are thus eliminated. For instance, as *per-unit* quantities, current is taken as numerically equal to the m. m. f. of armature reaction, and voltage at normal frequency, as numerically equal to the magnetic linkages which produce it, and in many cases, as noted below, reactance as numerically equal to inductance.

The four basic concepts outlined in the foregoing paragraphs afford the basis for symmetrical, relatively

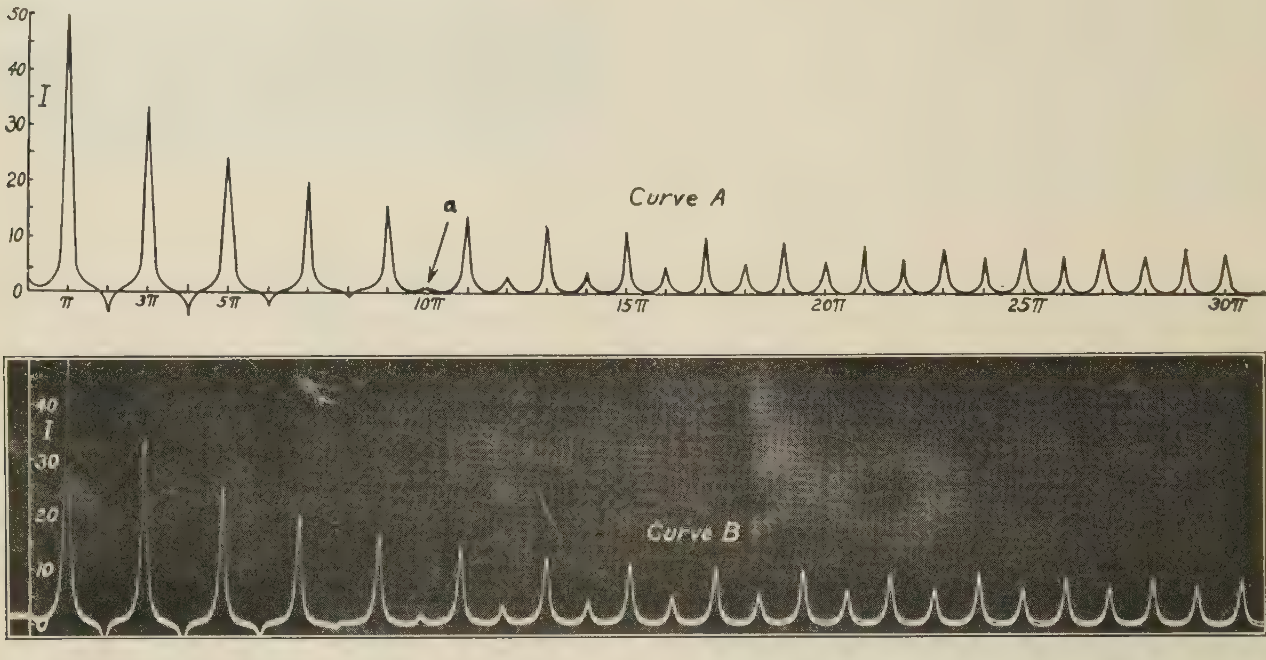

FIG. 16—TRANSIENT FIELD CURRENT, MAXIMUM INITIAL ARAMATURE LINKAGES ON SINGLE-PHASE LINE-TO-LINE SHORT-CIRCUIT 20-HP. MACHINE

A—Calculated curve
B—Test Curve

Equation: —

$$I = \frac{12.3 \cos t}{3.98 - 3.56 \cos t}\, \epsilon^{-0.474t}\, \frac{3.08}{3\text{-}98 - 3.56 \cos 2t} + \frac{9.97}{3.98 - 3.56 \cos 2t}\, \epsilon^{-0132t}$$

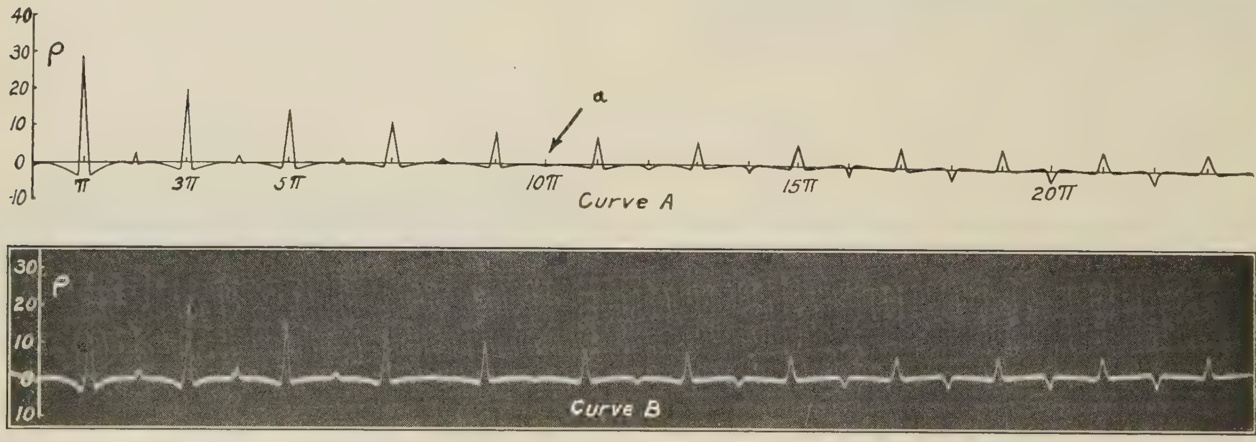

FIG. 19—TRANSIENT OPEN-PHASE VOLTAGE, MAXIMUM INITIAL ARMATURE LINKAGE ON SINGLE-PHASE LINE-TO-LINE SHORT-CIRCUIT 20-HP. MACHINE

A—Calculated curve
B—Test curve

Equation:—

$$e = -7.12\, \frac{(3.56 - 3.98 \cos 2t)}{(3.98 - 3.56 \cos 2t)}\, \epsilon^{-0.0474t} - \frac{1.78 \cos t - 3.36 \cos t \sin^2 t}{3.98 - 3.56 \cos 2t} + \frac{5.98 \cos t \sin^2 2t}{(3.98 - 3.56 \cos 2t)^2}$$

$$- \frac{(5.75 \cos t - 10.9 \cos t \sin^2 t)}{(3.98 - 3.56 \cos 2t)^2}\, \epsilon^{-0.132t}\, \frac{(19.3 \cos t \sin^2 2t)}{(3.98 - 3.56 \cos 2t)^2}\, \epsilon^{-0.132t}$$

simple, and very interesting expressions for the voltage and currents under single-phase operation. In this way, it has been possible without undue mathematical complications to take into account the *predominating factors* of the problem, and thus to obtain a very satisfactory agreement between calculated and test results, as may be seen by reference to Fig. 16 and others which follow.

These extensions, in theory, have required not only additional characteristic machine constants, (as already mentioned in a footnote), but, in order to avoid confusion and misunderstanding, they have made it also necessary to classify and more carefully define them. In the early days, a synchronous machine had *a* reactance; now it has many. Moreover, our ideas about some of the well established terms—for instance, *armature leakage reactance*, and *field leakage reactance*—have needed some revision. As a rough illustration in connection with the general situation,—in running a polygonal boundary, an error in the length or bearing of one of the sides is not so apparent, unless it becomes necessary to "close" the polygon. The error is merely passed on the next side, letting the end whip about as occasion may require. In synchronous machines, it was formerly necessary to "run" only one or two sides; now, with the necessity of calculating practically all of the electrical characteristics, we must "close the polygon." So, an orderly classification, a description, and a careful definition of terms is quite in order, as is also the presentation of methods of calculating some of these factors. The former is given in a companion paper by R. H. Park and B. L. Robertson; and the latter, by P. L. Alger.

Fundamental Equations

The general plan of attack and the general considerations leading up to the fundamental equations will be discussed here, and the final equations will be derived in the Appendix.

Superposition is used in obtaining the initial values of armature and field current. The plan is first to find a general expression for the magnetic linkages of the armature winding, due to any transient armature current, and with no field current, except that induced by the armature current; and then to determine the armature linkages due to any other current in the field winding, and superpose these to find the resultant value of armature linkages. Under short circuit, and neglecting resistance, the latter value of linkages must be equal to the known value existing at the instant of short circuit. These relations are sufficient to solve for the *initial* armature current i.

The *initial* value of field current is obtained by adding the component induced by the armature winding, to the steady value existing the instant before short circuit.

There are certain components of the *initial* current which are known to be transient. These, as a function of time, are obtained by multiplying the individual transient components by the appropriate decrement factor.

Of course the sustained values comprise those components which exist after the transients have disappeared, and thus are obtained by setting the transient terms equal to zero.

The decrement factors are obtained by an approximation. It seems to be well nigh hopeless, as a practical matter, to take into account rigorously the armature and field resistances, but it happens, fortunately, that it is possible to obtain results which are sufficiently accurate for any practical purpose, by making simplifying assumptions.

Results

The foremost result is the method of analysis which makes possible, in a practical way, the calculation of transient phenomena in a synchronous machine regardless of whether it is of the salient pole or the cylindrical rotor type. The equations thus derived have made it possible to calculate complicated transient characteristics which check, in the minutest details, with the oscillographic records of tests; and these equations have revealed a number of important and very interesting facts relating to the form of the current waves, the resulting possibility of relatively simple analysis of the waves, and the induced voltage in the open phase during single-phase short circuit. A summary of equation is given in Appendix A.

Referring to the short-circuit current waves, the current is expressed as the sum of two harmonic series, one of odd, the other of even, harmonics; and the *magnitudes of the harmonics in each series, in ascending order, are in geometric ratio.* Thus, the single-phase short-circuit current of the armature is

$$i = \frac{k\, e_0 \cos \alpha}{\sqrt{x_D'\, x_Q'}} [1 + 2\, b \cos 2\, (t + \alpha) + 2\, b^2 \cos 4\, (t + \alpha) + 2\, b^3 \cos 6\, (t + \alpha) + \ldots] - \frac{2\, k\, e_0}{x_D' + \sqrt{x_D'\, x_Q'}} [\cos (t + \alpha) + b \cos 3\, (t + \alpha) + b^2 \cos 5\, (t + \alpha) + b^3 \cos 7\, (t + \alpha) + \ldots] \qquad (9)$$

The geometric ratio b is given by

$$b = \frac{\sqrt{x_Q'} - \sqrt{x_D'}}{\sqrt{x_Q'} + \sqrt{x_D'}}$$

where x_Q' is the transient reactance in the quadrature axis, and x_D' the corresponding quantity in the direct axis; k = constant depending upon the phase which is short-circuited; e_0 = voltage before short circuit; α = angle at which short-circuit occurs; and t = time.

For instance, a 7000-kv-a., 375-rev. per min., 25-cycle, 2200-volt salient pole machine of usual construction has the following constants: $x_D' = 0.4$ $x_Q' = 1.0$ $b \cong 0.23$

In this machine, the 3rd harmonic in the short-circuit current would be 23 per cent of the fundamental, the

5th, 23 per cent of the 3rd, the 7th, 23 per cent of the 5th, and so on. Likewise for the even harmonics.

As an extreme case, $x_D' = 0.21\, x_Q' = 3.77\, b = 0.618$

These constants apply to an actual induction machine with a coil wound secondary. The armature is three-phase, the rotor two-phase; the latter, in this particular case, being connected two phases in series with d-c. excitation. The machine is rated 20 hp., 1800 rev. per min., 60-cycle, 110 volts. For convenience, the per-unit quantities are based on 10-kv-a., three-phase, and 57.7 volts line to neutral.

It is interesting to note that if $b = 0$, that is if $x_D' = x_Q'$, all harmonics disappear, and the current wave changes from the peaked wave in Fig. 13 to approximately a sine wave, as in Fig. 14.

Going a step further, x_D' can be made greater than x_Q' by placing external inductance in the field winding which is excited—*i. e.*, the direct axis winding. In this case the sign of the harmonics is reversed—*i. e.*, b becomes negative—, thus giving a dip in the wave. This is shown in Fig. 15.

So much for the results regarding short-circuit current. Turning now to the next major point in the results, the equations show that under single-phase short circuit the peak voltage across the open phase may be extremely high—many times normal in cylindrical laminated rotor machines without amortisseur winding. This voltage depends upon a very simple relation; namely, the ratio of x_Q' to x_D'. Thus, for a short circuit at $\alpha = 0$, that is at maximum flux enclosure, or maximun flux linkages, the ratio of the voltage across the open phase after short circuit (initial value) to the peak voltage before short circuit is

$$\rho_0 = \left(2\,\frac{x_D'}{x_Q'} - 1\right) \sin \beta \qquad (14)$$

where β is the angle between the axis of the short-circuited winding, and the axis of the open-circuited winding considered.

Thus, as an extreme case, consider the 20 hp. machine. Here the short circuit was line-to-line, and the voltage recorded was across the open-phase line-to-neutral. Thus $\beta = 90$ deg. The ratio for maximum flux linkages ($\alpha = 0$) therefore is,

$$\rho = \frac{3.77}{0.21} - 1 = 34.9$$

Reference to Fig. 19 will show that this *initial* value of over 34 times the voltage before short circuit, was obtained. The transient, of course, reduced the value of the first peak to obtain 28 times the value existing before short circuit, which value is also shown on the calculated wave.

Turning to the test on the 7000-kv-a. salient pole machine, the short circuit was line-to-line, and the open-phase voltage recorded was also line-to-line. Thus $\beta = 60$ deg., and from (14)

$$\rho = 3.46 \text{ for } \alpha = 0$$

and $$\rho = 2.16 \text{ for } \alpha = \pi/2$$

These are limiting values. In the test, the short circuit occurred at $\alpha = 2.2$ (*i. e.*, about 125 deg.) and therefore the peak should fall between those indicated by the above values of ρ. Using $\alpha = 125$ deg. (or, for convenience, the corresponding value, 55 deg.) in the equation of Appendix F, the calculated wave Fig.7 was obtained. The calculated first peak is 2.73 times the peak voltage before short circuit, and the corresponding test value, 2.97.

FEDERAL OPERATION PROPOSED FOR MUSCLE SHOALS

Effort is being made to have resolution S. J. 46, which has been favorably reported by the Senate Committee on Agriculture and which provides for Government operation of the power plants at Muscle Shoals and the utilization of income to be derived from the sale of power for the manufacture of nitrates for fertilizer, passed.

This resolution is somewhat the same as that introduced during the last session and is based upon the opinion that the manufacture of fertilizer by the cyanamid process, as contemplated in the equipment now available at Muscle Shoals, is not feasible from a commercial viewpoint. The theory is advanced that recent progress with the synthetic ammonia process makes it possible to manufacture nitrates by this latter process much cheaper than by the cyanamid process. Since the reporting of the measure, an amendment has been proposed to give Nitrate Plant No. 2 at Muscle Shoals to the American Cyanamid Company or the American Farm Bureau Federation on the condition that they agree to operate the plant at capacity for 50 years exclusively for the manufacture of fertilizer. Also, an amendment has been introduced proposing a considerable extension of a distribution system which might be operated by the Government should this measure be enacted into law.

AIR SERVICE TO BE INSPECTED BY DISTRICTS

To expedite inspection and the examination and licensing of aircraft and airmen, the United States has been divided into sixteen inspection districts, each of which will be in charge of an inspector of the Air Regulation Division, Department of Commerce. Headquarters will be established in each district to help in the investigation of accidents as well as conduct the work referred to above.

Abridgment of

Condenser-Type Bushing

Used With Synchronizing Equipment

BY E. E. SPRACKLEN[1] D. E. MARSHALL[2] and P. O. LANGGUTH[2]
Member, A. I. E. E. Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.*—This paper describes apparatus recently developed for utilizing the charging current of a condenser bushing in operating a synchronoscope, thus making a simple and inexpensive method of synchronizing at high voltage. Data are given also covering the operation of the device for different conditions of frequency, voltage, etc., thus assisting in the consideration of the adaptability of the device to other applications. An account of the first installation in the field is also given.*

THE rapid advancement of superpower systems has increased the demand for a simple and economical high-voltage synchronizing device.

In order to meet this demand, there has been developed a condenser-bushing potential device which utilizes the inherent capacity potentiometer characteristics of the bushing in providing a source of low voltage which can be used in synchronizing.

This device is relatively inexpensive, simple, easy to operate, requires small space, and is sufficiently accurate for most synchronizing applications.

General Theory of Bushing Potentiometer

In general, a successful insulator potentiometer must have two qualities; it must be of a relatively high capacity and must be protected from the weather.

These two requirements are met by the condenser bushing. Constructed as it is of concentric metal-foil cylinders about the high-voltage conductor, it forms an ideal capacity potentiometer wherein the metal-foil cylinders are plates and the micarta is dielectric of a series of condensers which can be considered as connected in series from the high voltage to ground. By adding a tap to the last step to ground, a potentiometer is easily obtained. Its size assures ample capacity for instrument indication and it is completely protected from the weather.

As these bushings are designed for a voltage drop of approximately 4000 volts per layer, some means must be provided for lowering the voltage across the last step to the usual instrument voltage of about 110 volts. This may be done either by paralleling the last step with a condenser of sufficient size or by the use of a potential transformer.

The transformer method is the better as it allows a greater current to be drawn from the potentiometer than does the condenser method. With the transformer alone, however, only devices which are specially calibrated can operate with accuracy. Any instrument having resistance in its circuit will cause the instrument voltage to be out of phase with the line voltage. This is shown in Appendix I. However, a modification of this method, in which the terminal voltage and phase-angle error are practically independent of the burden of the connected instrument, may be applied.

This modification is effected by the addition of a reactor tuned to resonance with the capacity of the last step of the bushing less the transformer exciting reactance, as shown in Fig. 1.

From the theoretical discussion of this circuit, as given in Appendix II, it is seen that the voltage ratio is approximately independent of instrument impedance and the phase angle between line and terminal voltage is approximately zero.

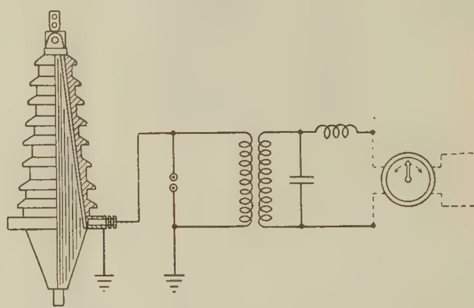

FIG. 1—COMPLETE SCHEMATIC DIAGRAM OF CONDENSER BUSHING POTENTIAL DEVICE

Commercial Form of Device

As the name of the device implies, the condenser bushing is used to supply a source of potential. Fig. 2 illustrates in detail the method of tapping the last layer of the condenser bushing. A flexible cable having 7000-volt insulation is fastened to the last metal foil layer of the condenser, and extended to a moulded fitting in the bushing flange. This fitting is of the "plug" and "jack" construction, having the tapped lead attached to the "jack." All material and clearances are designed to retain the insulating properties of the condenser bushings, as at present, thus obviating any possible trouble between tap and ground. When the bushings are not connected to the potential device, a cap is provided for protecting the entrance to the "jack."

The potential device, itself, excepting the synchron-

1. Ohio Public Service Co., Cleveland, Ohio.
2. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

oscope, is assembled in a small protective sheet steel housing as illustrated in Fig. 3. It is suitably adapted for bolting directly to the circuit-breaker tank at a point near the condenser bushing tap. The connection between the tap and housing is approximately two to three feet in length, varying with the size of breaker. This connection consists of a 7000-volt insulated flexible cable protected within a flexible metallic water-proof conduit. Fittings are fastened to each end to permit ease of installation.

The equipment within the housing consists of a

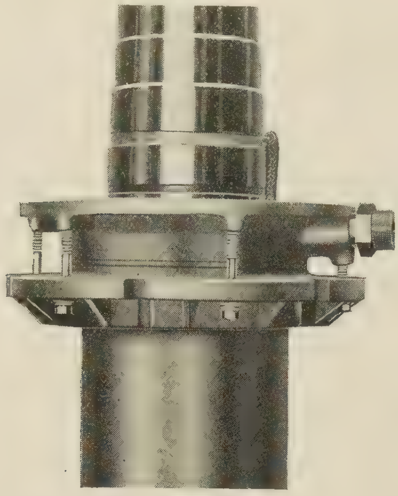

Fig. 2—Voltage Tap Construction on Standard Condenser Bushing

spark-gap arrester, low-voltage potential transformer, a reactor and a condenser. The energy discharge across the gap is small and permits the use of the usual spark-gap neutral arrester set to break down at a maximum voltage of 5500 volts. It is assembled within a porcelain casing and installed as shown in the upper left hand corner of the housing. Connection is made to ground through the protective housing of the device.

The outstanding point to be observed is the simplicity of the device. It is complete in one assembly and can be handled as a unit. The device is on the line at all times and operates continuously with no attention to either auxiliaries or secondary potential sources. The actual synchronizing operation is accomplished as easily as with a potential transformer.

Performance

Variations in service and burden conditions will cause variations in the performance of the condenser bushing potential device. Extensive tests were made to determine the performance under different conditions and to obtain an idea of the limitations of the device. The scope of this investigation included performance under such conditions as:

1. Variation of line voltage.
2. Variation of line frequency.
3. Variation of secondary burden.
4. Variation of temperature of condenser bushing.
5. Variation of line voltage wave form.

Also conclusive tests were made to demonstrate the adequacy of this device for high-voltage synchronizing.

Performance Obtained with Synchroscope. A set-up was made to determine the operation of the synchronoscope with this device subjected to various conditions. Fig. 4 shows the phase-angle performance that may be obtained with variation in frequency of the line voltage. This information was obtained, using similar condenser bushing potential devices on either side of the synchronoscope operated from the same line voltage source. The angular error is the deflection of the synchronoscope needle. This curve shows that the phase-angle error is negligible when using two potential devices for synchronizing.

In Fig. 5 is shown the phase-angle performance when an attempt is made to synchronize with a condenser bushing potential device on one of the lines to be synchronized, and a potential transformer on the other. The phase-angle error is permissible for synchronizing in the region of 60 cycles, but for greater ranges of frequency, the device should not be used when balanced against a potential transformer. The variation of phase angle, in either case, is practically unaffected by variation in line voltage. The voltage performances obtained with a synchronoscope burden are illustrated in Fig. 6. Here, again, a constant voltage ratio is

Fig. 3—Housing with Cover Removed Showing Network

obtained for a given frequency. The performance with variable frequency is comparable to that discussed under effects of frequency. It appears, therefore, that the frequency variation will cause very little change in the voltage at the synchronoscope terminals. In general, these performance data indicate that synchronizing with the potential device on both sources to be synchronized will be just as reliable as is obtained in potential transformer practise.

Application

This device may be applied to the standard condenser bushings assembled on circuit breakers, power transformers, or in separate containers, with the following limitations in burden, depending on primary voltage:

1. 88-kv. Line Voltage—10 volt-ampere, based on 110 volts.
2. 110-kv. Line Voltage—12 volt-ampere, based on 110 volts.
3. 132-kv. Line Voltage—15 volt-ampere, based on 110 volts.
4. 154-kv. Line Voltage—20 volt-ampere, based on 110 volts.
5. 220-kv. Line Voltage—30 volt-ampere, based on 110 volts.

These limitations are given for 60-cycle service. For 50-cycle service, the burdens will be reduced to five-sixths of the above values. For 25-cycle service, the device should only be applied to the higher voltage bushings since the maximum burden permissible is but 40 per cent of the 60-cycle limits.

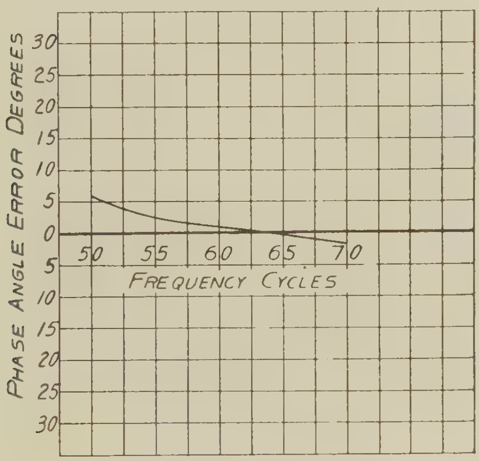

Fig. 4—Phase-Angle Error When Synchronizing with Two Condenser Bushing Potential Devices (Test Data)

In case greater secondary burdens than those above are to be used, two potential devices on the same breaker can be used in parallel per phase, thus allowing double the burden given above.

The use of a potential transformer on one line to be synchronized, and a condenser bushing potential device on the other, is not recommended. Station layouts should be made to anticipate the use of a condenser bushing device on each of the lines to be synchronized. Under this condition, the maximum phase-angle differential that may be expected between any two condenser bushing devices throughout the commercial frequency range, (50 to 70 cycles), is six degrees. This error is due to possible manufacturing variations within the potential device, itself, and is designed to be practically zero at 60 cycles. This small variation in phase-angle error will not interfere with the usual synchronizing operation.

Other Applications

There are several other uses of the condenser bushing potential device in addition to synchronizing. The

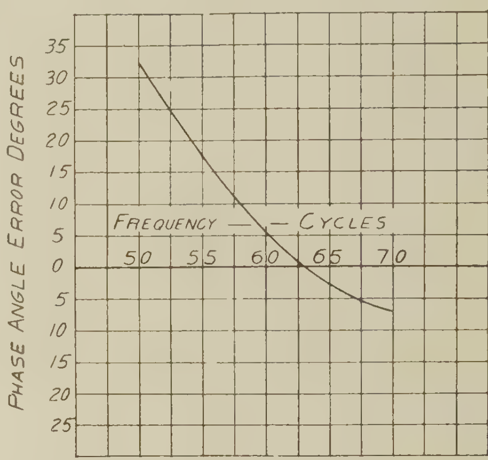

Fig. 5—Phase-Angle Error When Synchronizing with Condenser Bushing Potential Device and Potential Transformer (Test Data)

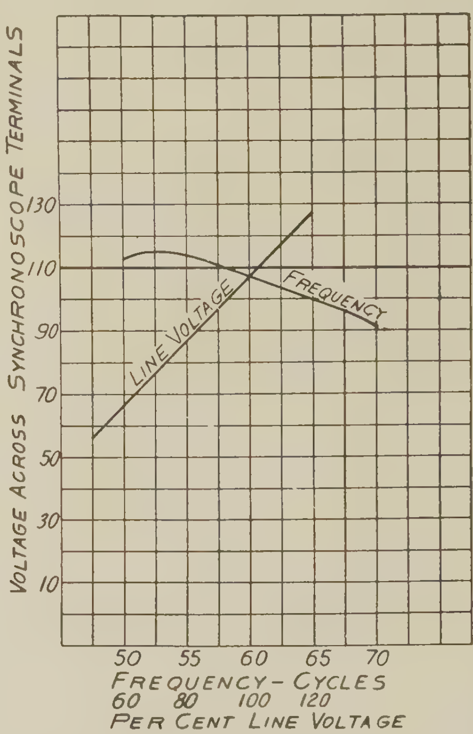

Fig. 6—Voltage Across Synchronoscope Terminals for Variations in Line Voltage and Frequency (Test Data)

same limitations with regard to phase-angle and voltage performances, as above mentioned, will apply here also. In general, on applying this device the maximum permissible burden should not be exceeded; otherwise the condenser bushing, itself, will be affected by unduly increasing the voltage across the tapped layer.

The potential device gives a very satisfactory indication of voltage although not sufficiently accurate for power measurements.

Voltage indication may be obtained between phase and ground or between phases, depending upon the relative connection of the secondary of the devices on the different phases. Standard switchboard voltmeters can be used with this device for giving voltage indication and connected the same as when using potential transformers. Curves similar to those given under performance can be used as a calibration if necessary.

Frequency indication of a high-voltage line is also easily accomplished by use of the potential device. Inasmuch as there is no frequency change within the device, a true indication of frequency will be given. The standard switchboard frequency meter can be used within the burden limitations of the device and handled the same as when using the potential transformer.

Probably one of the most important future applications of the condenser bushing potential device will be in the relay field. Generally, the device may be used in place of potential transformers for operation of potential relays provided the phase-angle and voltage performance characteristics are satisfactory for proper functioning. In view of the fact that the device operates continuously, a potential source is always present. Due to simplicity and economy as compared to potential transformers, the use of relay schemes requiring potential should become more general. It will be particularly useful where protection is obtained by voltage indication between phase and ground, since the secondary voltage of the device is proportional to the voltage from phase-to-ground rather than between phases. This type of protection is in popular use on low-voltage circuits and its use has been hampered on high-voltage circuits due largely to the expense of potential transformers. Protection requiring the use of phase-to-phase voltage may also be obtained by proper interconnection of the secondary phase leads.

First Installation

The first installation of this high-voltage synchronizing device has been made at the Bluebell Substation (Alliance, Ohio) of the Ohio Public Service Company with very satisfactory results.

Bluebell Substation is located near the center of a 132-kv. transmission line, 45 mi. long, between Canton, Ohio and Warren, Ohio. Since no other load is tapped from the line between Canton and Warren, synchronizing at either terminal point is possible without affecting the Bluebell Substation supply. This, however, requires that synchronizing be accomplished using low voltage circuits and necessitates considerable switching operation. At the time the station was built it was considered too expensive to install 132-kv. potential transformers for synchronizing purposes only.

During the spring of 1926 an Electrostatic Glow Meter was installed, to provide a means of synchronizing more rapidly, and with fewer switching operations. While this installation was quite economical, it was reliable only under favorable weather conditions.

In order to obtain a device operative under all conditions, the condenser bushing potential device was installed in August, 1927. The cost was but slightly in excess of the electrostatic glow meter installation cost and upon investigation it was found to be less than one-sixth the cost of a potential transformer synchronizing installation. This new scheme, although simplified, has all the advantages of the standard potential transformer scheme, but none of the irregularities of the glow meter scheme.

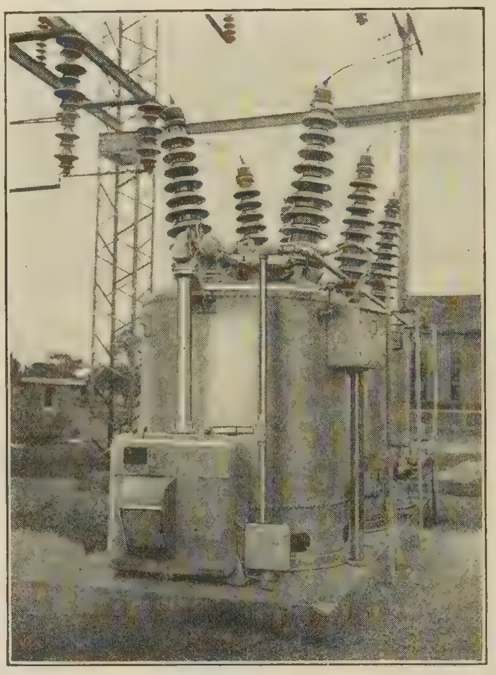

Fig. 7—Condenser Bushing Potential Device as Installed on Breaker Tank

The wiring diagram in Fig. 8 of the complete paper shows clearly the simplicity of the apparatus and the connections as applied to this installation. A standard synchronism indicator, except lamps and standard synchronizing plugs or switches, is used on the switchboard. One of the potential devices installed on a 132-kv. G-2 oil circuit breaker is also shown in Fig. 9.

It is the intention on future installations to synchronize across one pole of each breaker rather than from breaker to breaker in order to permit a greater flexibility in the switching set-ups and simplify switchboard connections. To date, 50 synchronizing operations have been made, using the two condenser bushing potential devices with no incorrect indications.

The Earth's Electric Charge

BY W. F. G. SWANN[1]

OUR earth is not a neutral body. It is coated with a layer of negative electricity of such amount that, at the surface, there is an electrical potential gradient of the order of 150 volts per meter. This potential gradient diminishes with altitude until, at an altitude of 10 kilometers, it becomes insignificant compared with its value at the surface. The potential gradient, and so the negative charge on the earth's surface, goes through fairly regular variations throughout the day and throughout the year; variations amounting to 50 per cent or more of its value.

The atmosphere is a very feeble conductor of electricity, so that there is a continual conduction of negative electricity from the earth's surface on account of the field. The conductivity of the atmosphere is extremely small. A column of air an inch long, at the earth's surface, offers as much resistance to the flow of the electric current as would a copper cable of equal cross-section extending from here to the star Arturus and back, twenty times over. Nevertheless, this small conductivity is sufficient to insure that 90 per cent of the earth's charge would disappear in 10 minutes if there were no means of replenishing the loss. The nature of this replenishment is the greatest of the outstanding problems of atmospheric electricity.

Many years ago it was suggested that the earth's charge might arise from negatively charged particles, or electrons, shot into our earth from the sun. The difficulty attending this explanation lies in the very great penetrating power which the corpuscles would have to possess in order to pass through our atmosphere, which is comparable, in absorbing power, with a column of mercury 76 cm. high.

For many years we have had information pointing to the existence of a very penetrating radiation of a hard ray type, which enters our atmosphere from outside and breaks up some of its molecules into positive and negative charges. The source of this radiation, is one of the most interesting speculations of cosmical physics today. By means of this radiation, it is possible to visualize one method by which the earth's charge may be maintained, for we know that when such rays eject electrons from atoms, they hurl them out in the directions of their own line of flight. The cosmic rays are like bullets fired downwards from a lot of guns in space, and the electrons which are knocked out of the atoms by these "bullets" continue their downward flight. Those electrons which are ejected from the upper regions of the atmosphere will be absorbed by the layers of air below; nevertheless, the earth will receive electrons from those layers of air which are, as it were, within striking distance of it. The farther the electrons are able to travel through the air without absorption, the greater the thickness of the atmosphere from which electrons will be fired into the earth. As a result of calculation, it appears that the replenishment of the earth's charge could be accounted for satisfactorily by supposing that each cubic centimeter of the atmosphere supplied three electrons per cu. cm. per sec. and that these electrons were of such speed that they could travel a distance of 9 meters in air without absorption. The emission of only one electron per cu. cm. per sec. would be sufficient, providing we were willing to assume for the electrons, a range of 27 meters, and such an assumption is not unreasonable. Two primary difficulties confront any attempt to explain the earth's charge through the agency of high-speed electrons shot into it. For we should expect such electrons to be capable of charging an insulated mass of metal exposed to their entry, but no such charging effects have been observed. A careful survey of the situation shows, however, that this difficulty is not insurmountable.

The second difficulty inherent in attempts to explain the earth's charge by high-speed electrons comes from the disruptive action which these corpuscles might be expected to produce in the air through which they pass. If these electrons should behave in a manner similar to that of such electrons as we meet in the laboratory, a stream of them strong enough to maintain the earth's charge, on passing through the atmosphere, would produce 10,000 times as much disruption therein as our measurements of atmospheric conductivity show to occur. A closer scrutiny of this matter, however, shows us how we may relieve ourselves of the difficulty. For it appears that electrons which travel with a velocity very nearly equal to that of light,—that is to say, very nearly 186,000 mi. per sec.,—would have properties vastly different from those of electrons of slightly less speed. The electromagnetic theory teaches us that if a swiftly moving electron should disrupt an atom as it passes, it would have to pay a sort of tax in the shape of energy radiated, and this tax would be greater the greater the velocity of the electron. To put the matter in a way which appears to endow the electron with characteristics perhaps too humanistic, but which, nevertheless, have their counterpart in the cold criteria of mathematical theory, the electron knows the tax which it will be expected to pay, and if its velocity is high enough, that tax will be too great and the electron will know how to avoid disrupting the atom at all. It turns out that the velocity which an

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1. Director of Bartol Research Foundation, Franklin Institute.

Lecture delivered at Winter Convention of the A. I. E. E., New York, N. Y., February 13, 1928.

electron would have to attain in order that it could avoid disrupting the atoms of air through which it passes is only 45 meters per sec. less than the velocity of light. This happens to be just the velocity which Birkeland calculated many years ago as the velocity which electrons entering our atmosphere would have to have if they could account satisfactorily for the Aurora Borealis.

It is possible to adopt an entirely different view as to the origin of the earth's charge. Modern theory teaches us that the structure of matter is electrical; and a cubic centimeter of the earth contains so much positive and negative electricity that if these amounts could be separated and concentrated at two points one centimeter apart, they would attract each other with a force of a hundred million, million, million tons. A very, very slow but continual death of the positive electricity would leave a surplus of negative sufficient to provide for the atmospheric electric current. As a matter of fact, to account for the atmospheric electric current, it would be sufficient to assume a rate of death which was so slow that only one-half of one per cent of the earth's mass would disappear in a hundred million, million, million years. To merely postulate such a state of affairs without regard to the other facts of natural philosophy would be to run the danger which one would incur in things politic were he to alter one of the nation's laws without considering its bearing on everything else. It has been possible, however, to incorporate this idea of a slow death of electric charge as a result of the earth's rotation into a consistent scheme of electrodynamics, and at the same time to secure that the rotation shall provide an explanation for that other mystery, the earth's magnetic field. Moreover, it is possible to make this remolding of our physical laws so as to conform to the right ratio of the magnetic field of the earth to that of the sun. Further, the theory suggests a possible origin of the known magnetic fields of sun spots, magnetic fields 5000 times as great as that of the earth. Indeed, according to one interpretation of the theory the velocity of matter in the sun spots need be no greater than about 80 kilometers per sec. in order to provide for the magnetic activity which they exhibit. The planet Jupiter presents us with another heavenly body of interest for comparison for its diameter is eleven times as great and its angular velocity more than twice as great as that of the earth. The theory predicts for its magnetic field primarily two possibilities, a field twenty times that of the earth, or a field a hundred thousand times as great as the earth's field. The latter possibility, while speculative, suggests interesting possibilities as regards the kind of aurora which Jupiter might be expected to show and it is not inconceivable that the light of such an aurora may play a part in explaining certain peculiarities of the light which appears to be reflected from Jupiter's surface.

Ideals of the Engineer[1]

BY JOHN J. CARTY
Fellow, A. I. E. E.

IN receiving this great honor, I do so with feelings of deep gratitude and not without a sense of humility, for I realize that the brain of the individual has its limits as a storehouse, and that with knowledge continually increasing, any one mind can take in only a small portion of the rapidly accumulating body of engineering information. In these days, intellectual specialization is absolutely necessary, and whatever I have been able to accomplish is the result of specialization and the cooperation of many individuals.

In order to be of use to society, the ideas of the engineer, in every department,—transportation, communication, architecture,—must first be embodied in physical form, and because of this, he has achieved such a mastery over material things that he is regarded as preeminently the exponent of a material age. The great utility and economy resulting from his activities are so sensational as to conceal from view the ideals which form the basis of his creative work.

If seeking the truth and applying the truth to the affairs of man is a spiritual thing, then the engineer must be absolved from the charge of materialism. He is an advocate for truth; his works must be tried in the inexorable court of Nature, where no errors are committed and no exceptions granted. The work of the engineer is dedicated to the use of mankind, and the pecuniary compensation which he himself obtains is slight compared with the great benefits received by society. He finds inspiration and reward in achievement, and his real compensation is the good which others derive from what he has done.

Let us consider briefly the ideals of the engineer and the nature of his functions in the light of modern theories of evolution.

We are told that man has come from lowly origin, and that during ages of time incalculably long, he has advanced to his present position at the head of the animal kingdom. It has been supposed that in man, himself, this evolutionary process is still at work, and that therefore in the course of the ages, he will evolve into a superlative type and then, perhaps, all will go well.

Inasmuch as this evolutionary process in man himself is said to have taken vast periods of time, it is not

1. Address delivered at Presentation of John Fritz Medal to General John J. Carty, at A. I. E. E., Winter Convention, New York, N. Y., February 15, 1928.

unreasonable to expect that further ages must elapse before salvation by this form of evolution could be achieved.

Such a view does not afford much comfort to us, nor does it provide any basis for a practical program to guide us. Even speaking in terms of the life of a nation, such a process is too slow. We must reckon with man as he now is. Our problems must be solved by working upon him and through him, and cannot wait for the arrival of the hypothetical superman. Indeed, it is stated by an eminent authority that there are no indications that the future man will be more perfect in body than the most perfect individuals of the present, or than the most perfect men and women in the days of Phidias and Praxiteles. There seems to be no general agreement as to whether this process in man himself has actually ceased; but I believe it is safe to say, in any event, that it is too slow in its operation to afford a solution of any of the problems that now confront us.

This, however, is not all that evolution has to offer. For even if this one pathway should be closed to further great progress during our age, we are assured by that eminent authority, Professor Edwin Grant Conklin,[2] that there are two others which are open to us.

The first of these to be considered is one which is preeminently under the control of the engineer. Conklin tells us that the evolution of man, the individual, is no longer limited to his body or mind; but by adding to his own powers the forces of nature, man has entered upon a new path of progress. The differentiations of various members of a colony of ants or bees, he tells us, are limited to their bodies, and are fixed and irreversible. But in human society, differentiations are no longer confined to the bodies of individuals, but have become, as it were, extra-corporeal. And by his control over nature, man has taken into his evolution the whole of his environment. Although he is not as strong as the elephant, nor as deft as the spider, nor as swift as the antelope, nor as powerful in the water as the whale, nor in the air as the eagle; yet, by his control of the forces of nature outside of his body, he can excel all animals in strength and delicacy of movement, and in speed and power, on land, in water, and in air.

The true object of engineering is not to create machines to which men will be bound by the chains of necessity, or mechanisms to which they will become slaves. The mission of the engineer is to obtain such a mastery in the application of the laws of nature, that man will be liberated, and that the forces of the universe will be employed in his service. According to Conklin, this new path of progress is in all respects the most important which has ever been discovered by organisms, and no one can forsee the end of this process of annexing to our own powers the illimitable forces of the universe.

2. The Direction of Human Evolution, by Edwin Grant Conklin, (Scribner, pub. 1921.)

Concerning the other pathway of evolution, he tells us the progress in intellectual evolution, no less than in physical, lies in the direction of increasing specialization and cooperation. But this progress, he says, is no longer taking place within the individual, but in the specialization and cooperation of many individuals. The intellectual evolution of the individual may have come to an end; but whether or not this is true, it is certain that the intellectual evolution of groups of individuals is only at the beginning. In social evolution—the evolution of human society—Conklin says a new path of progress has been found, the end of which no one can foresee.

Progress along this pathway, also, is vitally dependent upon the work of the engineer, for the perfection of all forms of communications and transportation is essential in order that this new superorganism, human society, shall achieve its destiny.

Emphasizing the importance of this, Trotter,[3] another distinguished writer on evolution, tells us that the capacity for free intercommunication between individuals of the species has meant so much in the evolution of man, and will certainly come in the future to mean so incalculably more, that it cannot be regarded as anything less than a master element in the shaping of his destiny.

The use of the spoken word to convey ideas distinguishes man from all other created things. It is the function of the engineer to provide for the extension of the spoken word by means of electrical systems of intercommunication which will serve to connect the nervous system of each unit of society with all of the others, thus providing an indispensable element in the structure of that inconceivably great and powerful organism which it is believed will be the ultimate outcome of the marvelous evolution which society is to undergo.

There is one element, and only one, which stands in the way of realization of this inspiring vision. That is man himself, for he is the unit or cell out of which the new organism is to be evolved. In the individual animal organism, the units or cells are physically joined to each other; but in the social organism, the units are individuals, not physically joined, but free to move about at will. The connection between these separate and mobile units is accomplished by communications, which convey information, ideas, and impulses from one mind to another. Whether these communications shall be employed in peaceful, constructive cooperation, or whether they shall be used to engender conflict and confusion, depends upon man himself.

Already, the applications of science to human affairs have far outrun the ability of man to use them wisely. The engineer has provided agencies of incalculable value in time of peace, but they are also endowed with prodig-

3. Instincts of the Herd in Peace and War, by W. Trotter. (Macmillan, pub. 1926.)

ious powers of destruction which can be loosed in time of war. Unless we solve the problem encountered in man himself, the outlook is dark indeed, and it may even be questioned whether our civilization will endure.

Human behavior presents the most important and the most formidable problem of all the ages. Its solution can be achieved only by profound and prolonged researches, which shall bring to bear upon every phase of the subject all of the resources of science.

While, in such a consideration as this, it would be folly to ignore the claims of religion and philosophy, it would be a grave error to conclude that, in order to avoid disaster, we must restrict progress in the application of science to material things. On the contrary, we must accelerate progress in all the sciences, for the knowledge thus gained will be required in preparing the individual man to function as a sane and peaceful unit in the ultimate social organism.

Scientific research in our universities and elsewhere, conducted solely, for the increase of knowledge, should receive more adequate financial support, so that it may be prosecuted with ever-increasing vigor. If this is done, I believe that in the fulness of time, by further scientific discoveries, the physical development of man will be improved, that many diseases will be entirely eliminated, and that immunity to the others will be achieved, and that feeble-bodiedness and feeble-mindedness will disappear. Thus will be removed some of the greatest barrirs to social progress.

In the great plan of evolution, the part assigned to the engineer calls for the highest exercise of his creative faculties, for he is to direct the evolution of man's extracorporeal powers, providing him with more numerous and still more powerful additions to his feeble bodily equipment.

The ideals of the engineer will not be realized until man has achieved his destiny in that social organism which is foreshadowed "with its million-minded knowledge and power, to which no barrier will be insurmountable, no gulf impassable, and no task too great."

Use of Very High-Voltage in Vacuum Tubes[1]

BY W. D. COOLIDGE

Associate, A. I. E. E.

I SHOULD like to say a few words this evening about a subject which has interested me deeply for several years; namely, the use of very high-voltage in vacuum tubes.

Early in our work on the hot cathode high-vacuum X-ray tube, we were made conscious of a certain limitation. Such a tube behaved consistently only so long as a certain applied voltage was not exceeded. When this voltage *was* exceeded, current flowed through the tube even when the cathode was not heated. This current increased rapidly as the applied voltage was increased. Depending on the design of the tube, the discharge might pass directly from one electrode to the other, or it might pass from one electrode to the glass wall of the tube and then to the other electrode.

The discharge was shown to consist of tiny jets of electrons coming from the cathode. When these jets went directly to the anode, their points of impact could be recognized by the heating, fluorescent, and X-ray effects which they produced. When they impinged upon the glass, they produced the small fluorescent patches familiar to those who have worked with the original gas-filled X-ray tube when the latter had too high a vacuum to function properly. In the hot cathode X-ray tube the discharge in question took place from the edges of the focusing device and, by means of the X-ray pinhold camera, it was easy to show that it was quite independent of whether the filament was lighted or not.

Experiment showed that the determining factor was not the magnitude of the applied potential difference, but rather the electrical *potential gradient* at the surface of the cathode. The cold cathode discharge was favored by close spacing of electrodes and by the presence of sharp edges and corners on the cathode structure. While our first acquaintance with the effect had been made at voltages of the order of magnitude of a hundred thousand, we found later that by placing the electrodes only a few mils apart and letting the cathode consist of a tiny wire, say one mil in diameter, the cold cathode effect could be observed with only a couple of thousand volts.

It was as though electrons could be pulled out of the cathode by the application of a sufficiently strong electrostatic field.

The cold cathode effect sets a limit to the voltage which can be used on a given tube, for if one attempts to appreciably raise voltage in spite of it, he either punctures the tube, through the local heating attending bombardment of the glass, or gets a runaway arc discharge, through bombardment of the anode.

In our earlier attempts to build experimental X-ray and cathode ray tubes for voltages appreciably in excess of 250,000, we have seemed to be continually contending with and limited by the "cold cathode" effect.

More recently we have found that we can remove this

1. Address delivered at Presentation of the Edison Medal to Dr. Coolidge at the A. I. E. E. Winter Convention, New York, N. Y., February 15, 1928.

limitation, by subdividing the total potential difference applied to the tube between different pairs of tubular electrodes. The electrons coming from the cathode are then given successive accelerations as they pass between successive pairs of electrodes. This in effect divides the tube up into sections each of which may be good for as much as 300,000 volts. We have already successfully operated such a cathode ray tube, with three sections, on 900,000 volts.

This cascade, or multi-sectional system, promises to let us build vacuum discharge tubes for as high voltages as we can generate. This applies as well to an X-ray tube as to a cathode ray tube, as the latter may be converted into the former by the addition of a suitable target. It also applies equally well to a high-voltage kenotron.

This opens a vista of alluring scientific possibilities. It has tantalized us for years to think that we couldn't produce in the laboratory just as high speed electrons as the highest velocity beta rays of radium and just as penetrating radiations as the shortest wavelength gamma rays from radium. According to Sir Ernest Rutherford, we need only a little more than twice the voltage which we have already employed, to produce X-rays as penetrating as the most penetrating gamma rays from radium, and about three million volts to produce as high-speed beta rays. The capacity or quantity factor would be tremendously in our favor, as with twelve milliamperes of current we would have as many high speed electrons coming from the tube as from a ton of radium in equilibrium with its decomposition products. Another factor in our favor would be the control which we would have of the output. This would be quite different from our position with respect to radium, in which case no physical or chemical agency, at our command, in any way affects either the quality or the quantity of the output.

We expect to find that a high-voltage positive ray tube can be constructed along the general lines of the multi-sectional cathode ray tube. In this case, we should need, according to Rutherford, about eight million volts to produce positive rays having the energy of the highest velocity alpha rays from radium.

The problem of vacuum tube operation at very high voltages is a two-fold one, as it involves not only the design of the tube but also the design of a suitable high-voltage source.

It seems quite possible that it will prove advantageous to proceed along the lines of our present oil-immersed X-ray outfit, in which the X-ray tube is placed in the same container, and in the same oil, with the high-voltage source. With such an outfit, no part of the high-voltage circuit is brought out into the air, and the corona problem is therefore greatly simplified.

We now have transformers good for several million volts, even with the high-voltage circuit brought out into the air, and it should be possible for us to go much higher if the whole high-voltage circuit is kept in oil.

What shall we do with the high-speed particles obtainable from tubes operating at a potential difference of millions of volts? The lure, of course, lies in the fact that we can't answer the question, beyond saying that we shall experiment with them. They should eventually help us to further knowledge of the atomic nucleus and to further knowledge of radiation laws.

AUTOMATIC CONTROL BETWEEN CHICAGO AND OMAHA

The last stretch of Chicago & North Westerns' main-line automatic train control installation, extending from Chicago to Omaha, is scheduled to be complete and in service by May 1st.

This outstanding factor of safety and railroad efficiency marks one of the longest stretches of continuous automatic train control in the country, and with the completion of this vast improvement, all Chicago North Western trains on the main line will pass under an invisible master control that is absolutely automatic, holding the speed of all trains within proper limits at all times independently of the engineer or train men. Under any and all conditions of the weather, day or night, it safeguards the movements of all trains and provides engineers with a constant check as to speed, and the condition of the right-of-way ahead entirely independent of block system signals which are often obscured by fog thereby sacrificing speed for safety.

The new system allows an engineer to operate his passenger train as usual but at a speed within range of safety. The maximum speed for freight trains by this system of control is fifty miles per hour, if the track is clear. Should an engineer approach too closely a train or other unexpected restricted conditions ahead, the invisible master control causes a warning light in the cab to change from green to yellow, at the same time sounding a chime or warning whistle. This double automatic warning of light and sound must be immediately acknowledged by the engineer in charge of the train. The speed of his train is forthwith reduced to below twenty miles an hour, otherwise the brakes will be automatically applied, the control taken from his hands and the train stopped. As soon as the track ahead is clear again, the master control signal informs the engineer of the fact, whereupon he can again proceed at full speed ahead, up to within the required safety margin of seventy miles per hour for passenger service.

The Chicago & North Western was the first railroad to install continuous automatic train control on so large a scale and at so great an outlay. Over 350 locomotives and 1050 miles of track had to be equipped with the control apparatus.

The Clinton-to-Omaha installation was completed and in operation July 1, 1927. Engineers in charge of equipping the main line report that this new installation into Chicago will be complete and ready for service May 1st of this year.

Abridgment of

Certain Topics in Telegraph Transmission Theory

BY H. NYQUIST[1]
Member, A. I. E. E.

***Synopsis.**—The most obvious method for determining the distortion of telegraph signals is to calculate the transients of the telegraph system. This method has been treated by various writers, and solutions are available for telegraph lines with simple terminal conditions. It is well known that the extension of the same methods to more complicated terminal conditions, which represent the usual terminal apparatus, leads to great difficulties.*

The present paper attacks the same problem from the alternative standpoint of the steady-state characteristics of the system. This method has the advantage over the method of transients that the complication of the circuit which results from the use of terminal apparatus does not complicate the calculations materially. This method of treatment necessitates expressing the criteria of distortionless transmission in terms of the steady-state characteristics. Accordingly, a considerable portion of the paper describes and illustrates a method for making this translation.

A discussion is given of the minimum frequency range required for transmission at a given speed of signaling. In the case of carrier telegraphy, this discussion includes a comparison of single-sideband and double-sideband transmission. A number of incidental topics are also discussed.

* * * * *

Scope

The purpose of this paper is to set forth the results of theoretical studies of telegraph systems which have been made from time to time. These results are naturally disconnected and in order to make a connected story it has been necessary to include a certain amount of material which is already well known to telegraph engineers. The following topics are discussed:

1. The required frequency band is directly proportional to the signaling speed.

2. A repeated telegraph signal (of any length) may be considered as being made up of sinusoidal components. When the amplitude and phase, or real and imaginary parts, of these components are plotted as ordinates with their frequencies as abscissas, and when the frequency axis is divided into parts each being a frequency band of width numerically equal to the speed of signaling, it is found that the information conveyed in any band is substantially identical with that conveyed in any other; and the bands may be said to be mutually redundant.

3. The minimum band width required for unambiguous interpretation is substantially equal, numerically, to the speed of signaling and is substantially independent of the number of current values employed.

4. A criterion of perfect transmission is selected; and a discussion is given of the characteristics which the received wave must have to be non-distorting with the requirement that the frequency range should not be greater than necessary.

5. Directions are sketched for specifying systems to meet this requirement.

6. Several alternative criteria of distortionless transmission are considered and a method for computing the corresponding transmission characteristics of the circuit is explained and illustrated.

7. An analysis is given of the carrier wave, and it is shown that the usual carrier telegraph requires twice as much frequency range as the corresponding d-c. telegraph, other things being equal.

8. A discussion is given of two alternative methods for overcoming this inefficiency of carrier telegraphy,—namely, the use of phase discrimination and of a single sideband.

9. After the d-c. and carrier waves have thus been analyzed a corresponding analysis is given of an arbitrary wave shape, including these two as special cases. Calculations are given on the shaping of the transmitted wave so as to make the received wave perfect.

10. A discussion is given of the dual aspect of the telegraph wave. The wave may be looked on either as a function of ω, requiring the so-called steady-state method of treatment, or as a function of t requiring the so-called method of transients. It is shown that the steady-state theory can be made to yield the information necessary to specify the characteristics of an ideal system.

11. A discussion is given of the effect of interference and departures from ideal conditions.

The economy in frequency range, indicated under 2 and 3, should be considered as a theoretical limit which cannot be obtained in practise but which can be approached, the closeness of approach depending on the degree with which the requisite conditions are fulfilled. In practise, it is essential to limit the cost of terminal apparatus and this, in turn, may lead to imperfect utilization of the frequency range.

In certain portions of the paper the discussion is limited to ideal telegraph systems and it is the characteristics of such systems which are referred to above (4, 5 and 6). These ideal systems have certain ideal

1. American Telephone and Telegraph Co., New York, N. Y.
Presented at the Winter Convention of the A. I. E. E., New York, N. Y., February 13-17, 1928. Complete copies upon request.

transmission characteristics; while the reader is given sufficient information to specify suitable equilizers to produce an ideal system, there is no information given as to how to proceed to build equalizers to meet the requirements. It is not within the scope of the paper to enter into the practical questions of cost and detailed construction of signal shaping devices. While these subjects are of great importance, it is thought best to confine the paper to theory. Lest the reader should think this lack of equalizer theory a fatal weakness in

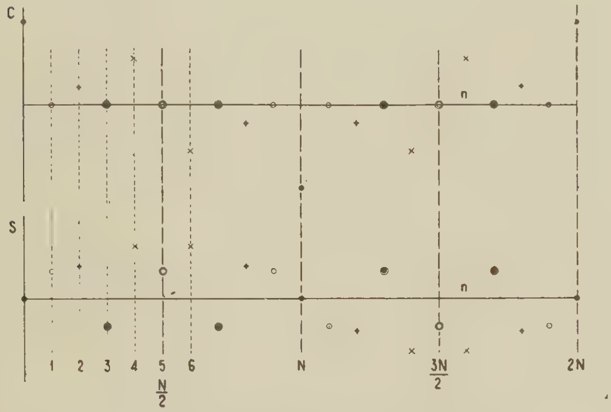


FIG. 1—DISCRIMINATION FACTOR OF *C* SIGNAL

Showing the symmetry and redundancy of successive bands. The corresponding points in the various bands are indicated by the same symbol

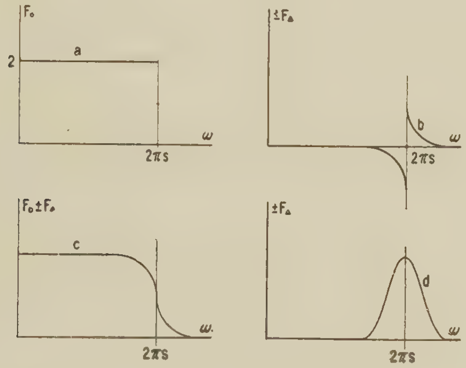


FIG. 2—IDEAL SHAPE FACTORS

Here the criterion for distortionless transmission is that the height of the middle of each signal element should be undistorted

a and *c* represent real shape factors which produce a non-distorting wave,—*b* and *d* shape factors which may be added without producing distortion, the former representing a real and the latter an imaginary value

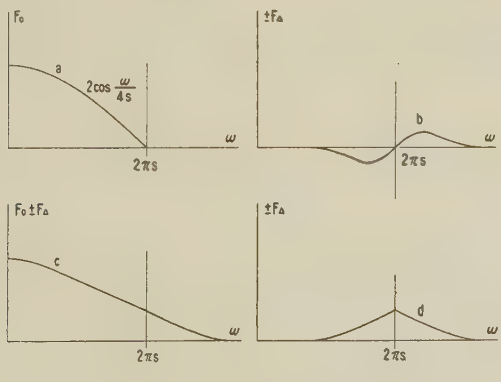


FIG. 3—IDEAL SHAPE FACTORS

In this figure, the criterion of distortionless transmission is that the width or duration of each signal element at the mean-value point should be undistorted

a and *c* represent real shape factors which produce a non-distorting wave,—*b* and *d* shape factors which may be added without producing distortion, the former representing an imaginary and the latter a real value

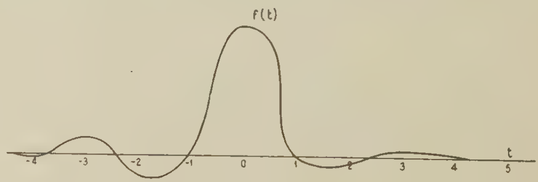


FIG. 4—SPECIMEN OF GENERAL WAVE FORM

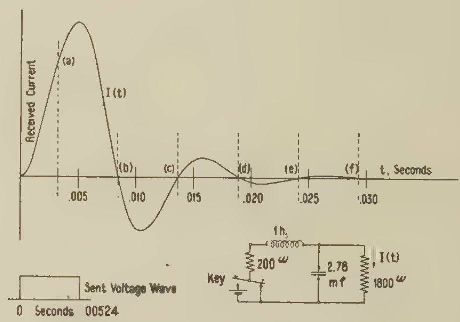


FIG. 5—INSTANCE OF NON-DISTORTING WAVE

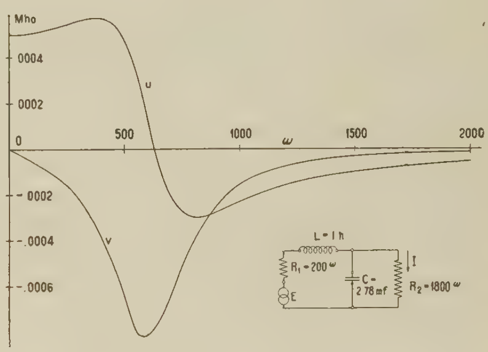


FIG. 6—TRANSFER ADMITTANCE, $u + i\,v$, CORRESPONDING TO THE NON-DISTORTING WAVE SHOWN IN FIG. 5

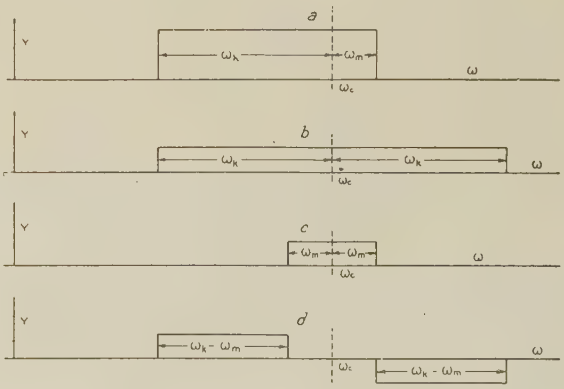


FIG. 7—GRAPHICAL ANALYSIS OF A TRANSMISSION CHARACTERISTIC

The sum of the transfer admittances shown at *b*, *c*, and *d* equals the transfer admittance shown at *a*. The components, *b*, *c*, and *d*, are chosen so as to possess symmetry about the carrier frequency

the whole theory presented, attention is called to the discussion of generalized wave shape; where directions are given for approaching the ideal case as closely as desired, by shaping the sent wave to take care of any residual imperfections in the transmission characteristic. Finally, under the discussion of interference,

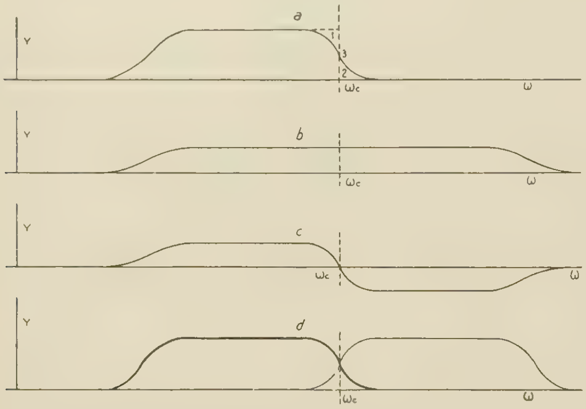


FIG. 8—GRAPHICAL ANALYSIS OF A TRANSMISSION CHARACTERISTIC

The sum of the symmetrical transfer admittances shown at *b* and *c* equals that shown at *a*. The heavy line in *d* is identical with the curve in *a*; the thin curve is the mirror image of the heavy one. The curve shown at *b* equals one-half the sum, and that shown at *c* equals one-half the difference of the two curves shown at *d*

mention is made of the effect of departures from the ideal in the matter of signaling speed, transmission characteristic, etc.

EXPLANATION OF THE FIGURES

Fig. 1 shows the successive harmonics of the *c* signal, which is made up of ten successive signal elements as follows: 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, where 1 denotes a mark and 0 a space. The values of the harmonics have been

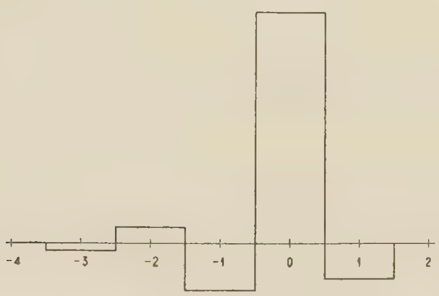


FIG 9—EXAMPLE OF SIGNAL SHAPING TO PRODUCE DISTORTIONLESS RECEIVED SIGNALS

multiplied by a known function of frequency. On comparing the harmonics indicated by the same symbols in the figure, it is made obvious that the harmonics above the fifth do not contribute any information about the signal beyond the information contained in harmonics up to and including the fifth.

Fig. 2 shows in what proportion the values of the harmonics given in Fig. 1 should be combined in order that the received signal wave should be non-distorting on a specific criterion of transmission. Fig. 3 is similar to Fig. 2 but applies to a different criterion for distortionless transmission.

By way of illustration, Figs. 5 and 6 give a nondistorting wave and its corresponding transfer admittance. The criterion for distortionless transmission in these figures is the same as in Fig. 2.

Figs. 7 and 8 are for the purpose of aiding the discussion of single-sideband telegraphy. They show how a given admittance may be subdivided into parts which possess symmetry relatively to an arbitrary frequency. By eliminating the waves due to certain of these parts the resultant received wave is made suitable for single-sideband transmission.

Fig. 4 illustrates the general type of signal element which is referred to in the paragraph numbered 9 under "Scope" above. Fig. 9 illustrates how a sent signal element may be shaped to compensate for distortion in the circuit.

LEGISLATION URGED TO CONSERVE OIL

Overproduction in the petroleum industry is causing such waste that the Special Advisory Committee of Nine in its report to The Federal Oil Conservation Board, has recommended that national legislation be enacted to curb this waste.

The Committee recommends that the proposed Federal legislation "shall unequivocally declare that agreements for the cooperative development and operation of single pools are not in violation of the Federal antitrust laws and shall permit, under suitable safeguards, the making, in times of overproduction, of agreements between oil producers for the curtailment of production." In the opinion of the Committee legislation similar to this would be enacted by the various oil-producing States.

A draft of a bill for submission to Congress was referred to the Federal Oil Conservation Board by the Committee of Nine. The conclusion of this tentative bill recommends that the Federal Oil Conservation Board be authorized to prescribe the necessary and proper rules and regulations "to do any and all things necessary to carry out and accomplish the purposes of this Act."

ELECTRICAL TESTING BUREAU FOR CANADA

The Canadian government is asking Parliament for permission to establish a Canadian Bureau of Standards, with director and facilities for the testing of electrical equipment and appliances of all kinds. Consent and cooperation of the provinces have already been obtained. Both Canadian and British have urgently applied to the government for such a bureau. Heretofore, in order to meet fire underwriter requirements, products of this section had to be subject to the approval of the United States Laboratories.

ILLUMINATION ITEMS

By Committee on Production and Application of Light

LIGHTING WARSHIPS

In a paper entitled "The Application of Electricity in Warships",* William McClelland deals with the present lighting practise on British ships. The subject is introduced with the following statement:

"During recent years, considerable advance has been made in the science of illumination, and the importance of adequate and proper lighting is now generally recognized. Bad lighting conditions cause eye-strain and inefficiency, react on the general health, and are responsible for many accidents.

"In a warship, conditions are such that officers and men must spend a large proportion of their time and do much of their work in artificial light. Even in daytime, comparatively few compartments in the ship can be provided with satisfactory natural illumination. Further, warship lighting problems are of a varied nature because of the diversity of use to which the compartments are put. There are, for instance, living spaces, offices, workshops, sick-bays, engine-rooms, boiler-rooms, numerous auxiliary spaces and store-rooms, in addition to special armament spaces, such as magazine and shell rooms, turrets and control rooms. A high standard of vision in the personnel is necessary for the efficient performance of their duties, and it is necessary that this high standard should not be impaired by inadequate or improper lighting."

The author then considers the lighting problem in warships, the illumination values desirable, and the types of fittings in use. The British Admiralty specifications for lamps provide for shock-testing lamps after they have burned for ten hours, and the apparatus in which this is done is described and illustrated. It has been the purpose to obtain a metal-filament lamp that will withstand gun shock and rough usage, and the author states that progress in manufacture has already made the use of carbon filaments unnecessary.

Average and minimum values of illumination for various compartments of British ships are specified and an abstract of illumination values for ships of the U. S. Navy is also included for comparison. The article states that the figures for British warships compare very favorably with shore practise and although considerably higher than previous values they are lower in certain instances, than they would have been had not other factors influenced the decision. (It appears that, in general, the standard of illumination specified for British ships is higher than for ours.)

Fittings are discussed under the headings of those used purely for illumination purposes, and those for special purposes, such as navigation lights, internal signaling, etc.

Searchlights are discussed with reference to the several important uses to which they are put today on shipboard. The types of lamps, reflectors, carbon electrodes, shutters, ventilators, reduction of pressure (voltage) and operation are dealt with briefly.

In addition to the application to lighting the many other uses of electricity on the modern warship are described at considerable length.

*Abstracted from *Journal of the Institute of Electrical Engineers*, Sept. 1927.

METHOD OF CALCULATING RHEOSTATS FOR THE CONTROL OF ILLUMINATION AND ITS PRACTICAL APPLICATION*

The design of rheostats for the control of illumination produced by incandescent lamps is complicated by the fact that the resistance of the filament varies considerably with changes in current which affects the distribution of voltage across the rheostat and the lamps. In the article here digested is described a graphic method which easily permits the exact determination of the sections of the conductors of such rheostats.

The characteristic curves, based on the relations of voltage and current and of luminous flux and current, are plotted in percentage values. The scales of the two curves are so related that the external resistance (in per cent of the resistance of the lamp when operated at normal voltage) required to produce any percentage of normal light flux can be determined graphically. The results obtained in three specific cases,—namely, (a) gas-filled lamps, wattages above 100; (b) gas-filled lamps, wattages below 100; and (c) vacuum lamps,—are given in tabular form to show the resistance (in percentage of the resistance of the lamp at normal voltage) that must be placed in series with the lamp to obtain various percentages of the normal light output.

Two examples of the utilization of the method in the calculation of resistances are treated in detail; the first based upon the reduction of illumination in equal amounts; the second, upon the reduction of illumination in steps following a logarithmic law.

The effect of operating a number of similar lamps in multiple with a common series resistance in studies and curves is given, showing the total luminous flux obtained with from one to six lamps with various values of resistance (expressed in terms of the resistance of a single lamp).

It is pointed out that when this external resistance is equal to 10.7 per cent, two lamps give no more light than one without resistance (*i. e.*, at normal voltage); and that when the resistance is 19.5 per cent, two lamps in multiple give no more light than one alone.

An actual case is cited to show how the increased voltage drop in a circuit containing some little resistance makes it impossible to increase illumination by increasing the wattage of the lamps operating thereon. Possible applications of the calculation of resistances to photometry and to theatre lighting are discussed.

*Abstract from article by Dr. N. A. Halbertsma and Mr. Edw. L. T. Matthews of the Philips Lamp Works, (*Revue Generale de l'Electricitie*, July 16, 1927.)

INSTITUTE AND RELATED ACTIVITIES

St. Louis Regional Meeting March 7-9

All plans are completed for the Regional Meeting which will be held March 7-9 in St. Louis, with headquarters at the Hotel Coronado. This meeting was announced in the February JOURNAL, page 154, and with the exception of substituting one technical paper, no changes have since been made in the arrangements. The change consisted in withdrawing the paper *Electric Equipment for Oil and Gas Locomotives* and placing in the program the paper *Drive of Tandem Rolling Mills*, by A. F. Kenyon, Westinghouse Electric & Manufacturing Company.

As already announced, the principal features will be a Branch conference, technical sessions on electrical machinery, power systems and communications, a dinner-dance and inspection trips.

Baltimore Regional Meeting April 17-20

The Middle Eastern District Regional Meeting, which will be held at the Hotel Belvedere in Baltimore April 17-20, should develop considerable interest in view of the excellent program of papers to be presented at the technical sessions, together with the inspection trips.

TECHNICAL SESSIONS

The technical papers will include the subjects of dielectrics and power generation. Dielectrics and insulation will be treated in one session of four papers. Papers will be presented covering the design of the Gould Street Generating Station of the Consolidated Gas, Electric Light and Power Company. Other papers will deal with the Conowingo development of the Philadelphia Electric Company, covering such features as the general design of the development, the 220-kv. transmission lines, quick-response excitation and stability calculations.

Details of the technical sessions are included in the accompanying program.

LECTURE OF DR. WOOD

One of the principal features of interest at this meeting will be a lecture on Tuesday evening, April 17 by Dr. R. W. Wood, Professor of Experimental Physics at Johns Hopkins University, on "Sounds that Burn."

INSPECTION TRIPS

On Wednesday afternoon there will be an inspection trip to the Gould Street Generating Station of the Consolidated Gas, Electric Light and Power Company. On Friday, April 20, there will be an all-day inspection trip to the Conowingo development of the Philadelphia Electric Company. Luncheon will be provided at Conowingo by the Philadelphia Electric Company.

ENTERTAINMENT

Arrangements have been made for the entertainment of the ladies throughout the meeting. On Tuesday afternoon, April 17, there will be a bridge party. On Wednesday afternoon there will be a trip to Annapolis and the Navel Academy.

Provision will be made for those members desiring to play golf on Wednesday and Thursday afternoons.

For those who may desire to form theater parties on Thursday evening, April 19, arrangements will be made for securing tickets.

DINNER-DANCE

On Wednesday, April 18, an informal dinner-dance will be held in the main ballroom of the Hotel Belvedere. During the dinner a number of interesting entertainment features will be provided.

HOTEL

All of the technical sessions will be held at the Hotel Belvedere. As the hotels in Baltimore are rather crowded at this time of the year, it is suggested that members expecting to attend this meeting make reservations as early as possible. Those desiring reservations should communicate directly with the manager of the Hotel Belvedere.

COMMITTEE

The general committee in charge of the meeting is as follows: J. L. Beaver, Vice-President in District 2, Chairman; Raymond Bailey, Secretary; M. R. Woodward, R. T. Greer, Leo Dorfman, L. G. Smith, R. C. Faught, Prof. L. A. Doggett.

PROGRAM

TUESDAY, APRIL 17

MORNING 10:00 A. M.

Registration — Committee Meetings

AFTERNOON 2:00 P. M

Technical Session

DR. J. B. WHITEHEAD, Presiding

Behavior of Dielectrics, R. R. Benedict, University of Wisconsin.

Thermal Method of Standardizing Dielectric Power Loss Measuring Equipment, J. A. Scott, H. W. Bowsman, General Electric Co. and R. R. Benedict, University of Wisconsin.

Developments in the Insulation of Coils for High-Voltage Turbo-Generators, C. H. Hill, Westinghouse Electric & Manufacturing Co.

Drying and Evacuating of Impregnated Paper Insulation, J. B. Whitehead, W. B. Kouwenhoven, F. Hamburger, Jr., Johns Hopkins University.

TUESDAY EVENING 8:00 P. M.

LECTURE

"*Sounds that Burn*," Dr. R. W. Wood, Johns Hopkins University.

WEDNESDAY, APRIL 18

MORNING 9:30 A. M.

Technical Session

W. S. GORSUCH, Presiding

The Gould St. Generating Station of the Consolidated Gas, Electric Light and Power Company, A. S. Loizeaux, Consolidated Gas, Electric Light and Power Company.

Design Studies for Gould St. Generating Station, F. T. Leilich, C. L. Follmer, R. C. Dannettel, Consolidated Gas, Electric Light and Power Company.

Operating Experiences, Gould St. Generating Station, A. L. Penniman, F. W. Quarles, Consolidated Gas, Electric Light and Power Company.

AFTERNOON 2:00 P. M

Inspection trip to Gould St. Generating Station.

EVENING 7:00 P. M.

Dinner-Dance.

THURSDAY, APRIL 19

MORNING 9:30 A. M.

Technical Session

W. S. GORSUCH, Presiding

The Conowingo Hydroelectric Development on the Susquehanna River, Alex. Wilson, 3rd, Philadelphia Electric Company.

Electrical Features of the Conowingo Generating Station and the Receiving Substations at Philadelphia, R. A. Hentz, Philadelphia Electric Company.

The 220-Kv. Transmission Lines for the Conowingo Development, P. H. Chase, Philadelphia Electric Company.

AFTERNOON 2:00 P. M.

Technical Session

W. S. GORSUCH, Presiding

Telephone System in Connection with the Conowingo Development, W. B. Beals, Chesapeake and Potomac Telephone Company and E. B. Tuttle, Bell Telephone Co. of Pennsylvania.

Quantitative Mechanical Analysis of Power-System Transient Disturbance, R. C. Bergvall and P. H. Robinson, Westinghouse Electric and Manufacturing Company.

Super-Excitation for the Synchronous Condensers for the Conowingo System, D. M. Jones, General Electric Company.

FRIDAY, APRIL 20

9:30 A. M.

Inspection Trip to the Conowingo Development.

Regional Meeting at New Haven May 9-12

The Regional Meeting of the District No. 1 will be held in New Haven, May 9-12 with the Connecticut Section as host. The Hotel Taft will be headquarters.

One of the sessions will be devoted to a joint symposium arranged by the Committees on Instruments and Measurements and on Protective Devices. It will deal with the instruments available for study and measurement of system disturbances and with the application of relays and other devices to control the effects upon system operation.

Three other sessions will be based on four unusual technical developments in the vicinity of New Haven which will have been about consummated by the time of the meeting. These are in the field of hydroelectric development, railroad, and street railway power and mercury turbines.

The Connecticut Light and Power Company is completing a development by which the excess flow of the Housatonic River will be pumped into a storage basin through utilization (a) on some occasions of a portion of the excess water power and (b) on other occasions of steam power from other points on the system. The result will be an equalization of the stream flow and progress toward a complete economic utilization of the entire river. This will be the feature of an all-day inspection trip on Saturday, May 12, and will also be covered by a paper by E. J. Amberg, of the Connecticut Light and Power Company. Similar papers dealing with corresponding development of other rivers in New England and the South are in preparation.

Power for the trolley system of the City of Bridgeport is now being supplied exclusively by mercury arc rectifier substations, one of which is entirely automatic. This will be the subject of two papers, one by G. E. Wood, of the Connecticut Company, on the principles and details of the installation, and a second by C. J. Daly, of the Southern New England Telephone Company, on the handling of inductive coordination between the railway feeder system and the local communication circuits.

The N. Y., N. H. and H. Railroad electrification is now being supplied with 25-cycle power through two variable-ratio frequency-changer sets, one deriving power from another 25-cycle system, and the second. power from a utility system at 60-cycles. This also will be the subject of an inspection trip and papers by Ludwig Encke of the Railroad and E. J. Burnham of the General Electric Company. C. F. Schuchart, Commonwealth Edison Company, and W. K. Vandersluis of the Illinois Central Railroad, will also present a paper on a similar phase of the Illinois Central electrification.

The 10,000-kv-a. mercury-boiler turbine at the South Meadows station of the Hartford Electric Light Company will be operating before the date of the sessions and there will be a paper describing that installation and discussion by the Company officers on the results of the operation. An inspection trip to this installation will also be made.

There will be another session including miscellaneous topics made up chiefly of "initial" papers by members of the District.

The Friday morning session will be turned over to the Branches of the Northeastern District for a student program, along the lines of that at Pittsfield, in 1927.

The three evenings will be devoted to a reception and dance, banquet, and theater party, respectively. Those attending the convention are to be given a complimentary performance by the Yale University Department of Drama, at the University Theater.

The Summer Convention, Denver June 25-29.

The 1928 Summer Convention of the Institute will be held June 25 to 29, in Denver, Colo., with headquarters at the Cosmopolitan Hotel.

At this date a program cannot be definitely announced, but it is proposed to have papers on high-speed circuit breakers and other equipment used on electrified railways, transmission-line surge investigations, carrier-current communication, geophysics, operation of electrical machines at high altitudes, engineering education, and other subjects. The annual reports and reviews of the Technical Committees will be given.

There will be also an annual conference of Section delegates.

A tour to Yellowstone Park and other places is being arranged in connection with the Convention as announced below.

Further details of the program will be published subsequently in the JOURNAL.

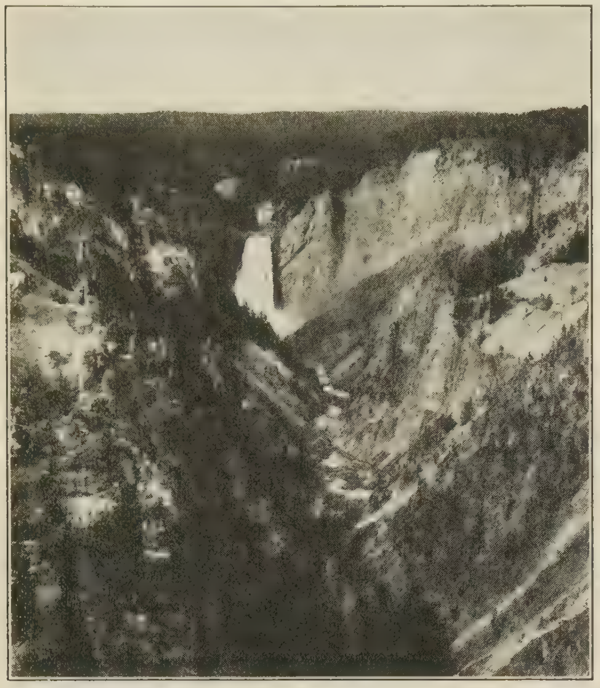
Institute Tour to Yellowstone Park

A tour of Yellowstone National Park, by way of Colorado Springs and Salt Lake City is being planned for Institute members and guests in connection with the 1928 Summer Convention to be held in Denver, Colorado, June 25-29.

SHOSHONE LAKE AND DAM AS SEEN FROM THE CODY ROAD

With New York City as a starting point, the entire trip will be made in about eighteen days, including, the time spent in Denver at the Convention. The time required from other points will depend, of course, upon their location. The start will be made from New York on the afternoon of June 22 and the return to New York will be on July 10.

The route from New York to Chicago will probably be over the New York Central, and on the route members may join the party on the train. Members from other sections of the country



GREAT FALLS AND GRAND CANYON OF THE YELLOWSTONE

may meet the party in Chicago or in fact at any other point on the route, including Denver.

The party will arrive at Denver on Sunday evening, June 23,

OLD FAITHFUL, YELLOWSTONE NATIONAL PARK

and after the Convention is over, will leave Friday evening, June 29, for Colorado Springs, where they will stay at the Broadmoor Hotel.

At Colorado Springs, June 30, Pike's Peak, the Garden of the Gods, South Cheyenne Canyon, and Seven Falls will be visited. Enroute from Colorado Springs on July 1 will be seen the famous Royal Gorge.

Arriving in Salt Lake City on the morning of July 2, trips will be made morning and afternoon, and at noon, the organ recital in the Mormon Temple will be heard. Among the trips which can be taken are those to Saltair Beach, the Bingham Copper Mines, and the canyons near the city.

Leaving Salt Lake City on the evening of July 2, the party will arrive at the West Yellowstone entrance on the next morning.

In Yellowstone National Park, four and one-half days will be spent enjoying the many wonders of nature which are there. Old Faithful and many other geysers, Yellowstone Lake, the Grand Canyon and Great Falls of the Yellowstone, Mammoth Hot Springs, Shoshone Lake and Dam are the prominent points that will be visited.

Leaving the park by way of the Cody road the party will take the train at Cody on the evening of July 7 and will arrive in Chicago July 9 and in New York, July 10.

A most enjoyable feature of this trip will be that all arrangements for railroad and pullman tickets, hotels, automobile tours, baggage transfer, etc., will be made by the travel bureau which has been authorized for the trip.

The cost of the tour, depending on pullman accommodations desired, will be as follows, with New York as the starting point. Rates from other points will differ according to the location.

COST OF TOUR STARTING AT NEW YORK

One in upper berth	One in lower berth	Two in compartment (each person)	Two in drawing room (each person)	Three in drawing room (each person)
$350	$375	$398	$439	$393

The tour is arranged on the all-expense plan and the cost includes round-trip railroad and pullman transportation, side trips, accommodations at first class hotels (rooms with bath, twin beds) including the Cosmopolitan Hotel, the headquarters of the meeting, all meals (except at Denver) transfer of passengers and baggage, sight-seeing and touring cars, in fact all necessary expenses except meals at Denver, trips in Salt Lake City and tips.

The cost does not include private baths at Yellowstone Park. Such accommodations are limited, but private bath accommodations will be secured for members of the party who desire them there, at slight additional cost.

All who are interested in this tour are requested to communicate with the travel bureau, The Henry Tours, Inc., 565 Fifth Avenue, New York, N. Y., which will make arrangements. The bureau will give information on all matters.

World Congress of Engineers, Japan

The American Committee of the World Congress of Engineers to be held in Tokio, Japan, November 1929, includes the names of E. W. Rice, Jr., past-president of the Institute and honorary chairman of the board of directors of the General Electric Company; Professor Elihu Thomson, past-president of the Institute and director of the Thomson Research Laboratory, Schenectady; C. C. Chesney, past-president of the Institute and vice-president of the General Electric Company; and Gerard Swope, Fellow of the Institute and president of the General Electric Company. This committee totals 78 members and is composed of many nationally prominent men. The four appointments here mentioned were made by Secretary Hoover.

This will be the first congress of its kind ever held, and has for its purpose the promulgation of international cooperation in the study of engineering science and problems, in the stimulation of a feeling of brotherhood among all engineers in the world.

The Sixteenth Winter Convention

The Winter Convention held in New York, February 13-17, followed the tradition of its predecessors in presenting a program of very substantial technical papers, but offered in addition a number of lighter features which attracted large and interested audiences. The total attendance of members and guests numbered about 2000.

Monday Afternoon

The technical session on Monday afternoon was held under the auspices of the Committee on Electrophysics, Professor Karapetoff, Chairman, and the general subjects of the papers were electrophysics and dielectrics.

The first paper presented was on *Surge Impulse Breakdown of Air*, by J. J. Torok, and was presented in abstract by the author.

The next paper was entitled the *Influence of Internal Vacua and Ionization on the Life Duration of Paper-Insulated, High-Tension Cables*, by Alexander Smouroff and L. Mashkileison of Leningrad, Russia. In the absence of the authors the paper was presented by Mr. Del Mar.

These two papers being on allied subjects were discussed together by Messrs. Del Mar, Fortescue, Duncan, Dawes, Slepian, Davidson, Salter, Connell, Peek, Lee and Wiseman, with closures by Messrs. Torok and Del Mar.

The next paper on the program was *Approximate Solution for Electrical Networks* by Mr. E. A. Guillemin, who presented this paper in abridged form.

The last paper of the session was entitled *The Boltzmann-Hopkinson Principle of Superposition as applied to Dielectrics*, by Prof. F. D. Murnaghan of Johns Hopkins University. This was abstracted by Dr. Slepian. The discussion which followed was by Messrs. Bush, LeGhait, Malti, Prof. Whitehead, (read by Mr. McEachron), and Slepian.

Monday Evening

The meeting was called to order by Professor Karapetoff who introduced the speaker of the evening, Dr. W. F. G. Swann, Director of the Bartol Research Foundation, Franklin Institute, who gave an interesting lecture on "The Earth's Electric Charge." At the close of his lecture, Dr. Swann consented to answer the questions which might be asked and considerable time was spent in explaining a number of points which were brought up by many in the audience.

Tuesday Morning

The technical session on Tuesday morning was under the auspices of the Committee on Power Generation, W. S. Gorsuch, Chairman, and the subject of the meeting was Interconnection and its effect on power development.

The session comprised four papers on various phases of interconnection by W. C. L. Eglin, W. E. Mitchell, P. M. Downing and H. B. Gear. Following the presentation of these papers a number of written discussions were presented by Messrs. A. C. Marshall, James Lyman, Farley Osgood, E. C. Stone, L. W. W. Morrow, W. S. Lee, C. F. Hirshfeld, F. A. Allner, with closures by N. E. Funk, W. E. Mitchell and H. B. Gear. The whole session formed a valuable symposium on the subject of Interconnection and the papers and discussions in full will appear in an early issue of the Quarterly Transactions.

Tuesday Afternoon

The session on Tuesday afternoon was on a variety of miscellaneous subjects and Mr. H. P. Charlesworth, Chairman of the Meetings and Papers Committee presided.

The first paper, *The Saturation Permeameter*, by S. L. Gokhale, was presented by the author and was discussed by Messrs. Kouwenhoven and Lippelt with closure by Mr. Gokhale.

The next paper was entitled *Manufacture and Magnetic Properties of Compressed Powdered Permalloy*, by W. J. Shackelton and I. G. Barber. It was presented by Mr. Barber, who illustrated his remarks with a number of lantern slides. The paper was discussed by Messrs. Jewett, Gherardi, Behrend, Fondiller and Herzog, with closure by Mr. Shackelton.

The next paper, *The Effect of Humidity on Dry Flashover Potential of Pin-Type Insulators*, by W. W. Shaver and J. T. Littleton, Jr., was presented by Mr. Shaver and discussed by Messrs. E. B. Clark and Harding.

The last item of this session was a lecture by Dr. Harold Norinder, of Upsala, Sweden, who spoke on the subject of the "Cathode Oscillograph as Used in the Study of Lightning and Other Surges on Transmission Lines." Dr. Norinder's lecture was illustrated with a large number of lantern slides, and the discussion was by Messrs. Roper and McEachron.

Tuesday Evening

Smoker

A very congenial evening was spent by the 600 present at the Smoker held on Tuesday, February 14, in the Belvedere Room of the Hotel Astor.

H. A. Kidder, the toastmaster, introduced in succession the Radio Tramp; a burlesque wrestling match; and the principal speaker of the evening, Strickland Gillilan, a humorist who created much laughter. Enjoyable music was furnished by the Brooklyn Edison Orchestra. The evening closed with a buffet supper.

Wednesday Morning

The morning session on Wednesday was held under the auspices of the Electrical Machinery Committee, Mr. F. D. Newbury, Chairman, Presiding. Three papers dealing with synchronous machines were first presented as follows:

Synchronous Machines—IV, by R. E. Doherty and C. A. Nickle.

Calculation of Armature Reactance of Synchronous Machines, by P. L. Alger.

Reactances of Synchronous Machines, by R. H. Park and B. L. Robertson.

These papers brought forth quite a voluminous discussion by Messrs. Kennelly, Lindner, Behrend, Treat, Lyon, Dawson, Hobart, Spencer, Shand, Henderson, Doherty and Park.

The last paper in the session, *The Thermal Volume Meter*, by G. W. Penney and C. J. Fechheimer was abstracted by Mr. Penney, and discussed by Messrs. Hobart, Dawson, Armadroid, Barns, Fechheimer closing the discussion.

Wednesday Afternoon

The technical session on Electrical Machinery continued Wednesday afternoon with four papers. Two of these were presented; first, *Recent Improvements in Turbine Generators*, by S. L. Henderson and C. R. Soderberg, and *Design and Application of Two-Pole Synchronous Motors*, by Messrs. D. W. McLenegan and I. H. Summers. A long discussion followed by Messrs. Foster, Behrend, Ross, Roth, Field, Merten, Owen, Williamson, Henderson, Soderberg, Summers and McLenegan.

The next two papers were then presented: *Effect of Transient Conditions on Application of D. C. Compound Motors*, by L. R. Ludwig, and *Heat Losses in the Conductors of a D. C. Armature*, by W. V. Lyon, E. Wayne and M. L. Henderson. The discussion which followed was by Messrs. Henderson, Park, Franklin, Behrend, Ludwig and Lyon.

Wednesday Evening

Wednesday evening was devoted to the presentation of the John Fritz Medal to General John J. Carty and the Edison Medal to Dr. W. D. Coolidge. Preceding the medal presentations, a dinner was given by the Institute to the medalists at the Engineers' Club, attended by more than fifty, including past medalists, members of the John Fritz and Edison Medal Boards of Awards, the presidents and secretaries of the Founder Societies, and members of the Board of Directors of the Institute. A

full account of the medal presentations is printed elsewhere in this issue of the JOURNAL.

THURSDAY MORNING

This session, which was held under the auspices of the Committee on Communications, included as its main feature the joint session with the British Institution of Electrical Engineers in London by means of transatlantic telephony, the technical and operating features of which were discussed before the joint meeting in papers presented by O. B. Blackwell and K. W. Waterson. Also, a motion picture "Voices Across the Sea," was shown. The film gave an insight into the principles involved, the apparatus required, and the routes that were followed in the combined land and transoceanic communication channels utilized for carrying out the joint session. A full account of the joint session itself is printed elsewhere in this issue of the JOURNAL.

Following the international meeting an intermission of ten minutes intervened, after which the meeting was called to order by Chairman Drake and the following paper was presented:

Loudspeakers of High Efficiency and Load Capacity, was the title of the paper presented by Mr. Hanna, who followed the presentation with a demonstration of a loudspeaker installed on the platform. A number of phonograph records were reproduced through this loudspeaker which gave a volume of sound quite out of proportion to the size of the engineering auditorium. This paper was discussed by Messrs. Fletcher, Kennelly and Jones, with a closure by Mr. Hanna.

The last paper in the session was entitled *Certain Topics in Telegraph Transmission Theory*, by H. Nyquist, and was presented in abstract by the author. As Mr. Nyquist's paper was of a type difficult to discuss orally, the Chairman advised that anyone prepared to discuss the paper should submit a written discussion. The meeting then adjourned.

THURSDAY AFTERNOON

Thursday afternoon was devoted to inspection trips, of which there was a great variety, fifteen separate trips being scheduled. A large number of visitors, however, took advantage of each of these trips. The Board of Directors also held its regular monthly meeting on Thursday afternoon. A brief resume is printed elsewhere in this issue.

THURSDAY EVENING

The annual Dinner Dance was held on Thursday evening in the Grand Ball Room of the Hotel Astor. The dinner was served at 7:30 and from 9:00 o'clock on, the seven hundred guests enjoyed dancing to the music furnished by the WEAF Vagabonds.

FRIDAY MORNING

The technical session on Friday morning was held under the auspices of the Committee on Protective Devices, Mr. F. L. Hunt, Chairman. In the absence of Mr. Hunt, who was unable to attend, Mr. H. R. Summerhayes presided.

The first paper was by Mr. O. J. Rotty, on *Automatic Control of Edison Systems*. This was discussed by Messrs. Antoniono, Lichtenberg, Summerhayes, Hough and Wallau, with closure by the author.

The next paper, *Protection of Supervisory Control Lines Against Overvoltage*, by Mr. Edward Beck, was abstracted by the author and discussed by Messrs. Floyd, Lichtenberg, Antoniono, with closure by Mr. Beck.

1926 Lightning Experience on 132-Kv. Transmission Lines, by Philip Sporn, was next presented by the author and discussed by Messrs. Kates, Austin, and Vincent, with closure by Mr. Sporn.

The next paper, *Vacuum-Tube Synchronizing Equipment*, by T. A. E. Belt and N. Hoard, was presented by Mr. Belt, who illustrated his presentation by means of motion picture films.

The last paper in the session, *Use of Condenser Type Bushing in Synchronizing*, by E. E. Spracklen, D. E. Marshall and P. O. Langguth, was presented by Mr. Marshall. Discussion followed by Messrs. Eby and Crumley with closure by Mr. P. O. Langguth.

FRIDAY AFTERNOON

The final technical session of the Convention was on Friday afternoon, the subject being Arc Welding and the papers were presented under the auspices of the Committee on Electric Welding, Mr. J. C. Lincoln, Chairman, presiding.

Mr. J. B. Green presented his subject by means of lantern slides and motion pictures. His paper was entitled, *Effects of Surface Materials on Metallic Arc-Welding Electrodes*, and described some research work which had been carried out by the author, covering quite a long period of time. Mr. Green's paper brought forth quite a large number of questions, which he answered at considerable length. The discussion was by Messrs. Morgan, Hobart, Lincoln, Wood, Gilmeyer, Dressler and Candy.

The next paper on the *Influence of Surrounding Atmosphere on the Arc*, by Mr. P. Alexander, was abstracted by the author and discussed by Messrs. Thomson, Herzog, Keel, Sheffer with closure by Mr. Alexander.

At the close of this discussion Chairman Lincoln exhibited apparatus which he had prepared, illustrating a phenomenon which had not been put in practical use, but which seemed to be of interest with regard to what happened in the arc which was exhibited. This experimental demonstration was discussed by Messrs. Churchward, Lampe, Thomson and the Chairman.

Next followed a paper by Mr. A. M. Candy on *Arc Welded Structures and Bridges*. This was discussed by Mr. Edwards.

The final paper of the Convention, *Welding and Manufacturing of Large Electrical Apparatus*, was then presented by its author, Mr. A. P. Wood. This paper was discussed by Messrs. Newbury, Barns, and Owens, after which a rather general discussion on arc welding ensued.

At the close of this discussion Mr. Charlesworth took the Chair and after a few brief remarks declared the Convention adjourned.

Summer School for Engineering Teachers

The Summer School for Engineering Teachers which was established by the Society for the Promotion of Engineering Education in 1927 is to continue its sessions during the coming summer. Two schools will be held: one for teachers of physics and the other for teachers of electrical engineering. As in 1927, when mechanics was the subject studied, the purpose will be to study the principles and methods of teaching rather than to review actual content of subject matter.

The session on the teaching of physics will be held at the Massachusetts Institute of Technology under the directorship of Dr. S. W. Stratton, President of the Institute. The session on electrical engineering will be held at Pittsburgh under the joint auspices of the University of Pittsburgh and the Westinghouse Electric and Manufacturing Company. Dr. F. L. Bishop of the University of Pittsburgh, Secretary of the Society for the Promotion of Engineering Education and Professor Charles F. Scott of Yale University, Chairman of the Society's Board of Investigation and Coordination will serve as Co-directors of the Pittsburgh session of the School. Professor H. P. Hammond, Associate Director of the Society's Investigation of Engineering Education is in general charge of the School. Both sessions will be of three weeks duration and will begin shortly after July 4. The success of the work in 1927, when it was necessary to restrict the enrollment because of the number of applicants, indicates that the sessions of 1928 will be well attended. The Society makes a nominal charge of ten dollars, as a registration fee. The schools are open to teachers of engineering students from any college or technical school in the United States or Canada.

Joint Session With the British Institution of Electrical Engineers

OWING to the deep significance and historic value of the joint session with the British Institution of Electrical Engineers held during the midwinter convention through the medium of transatlantic telephony, the proceedings of this meeting are published herewith in full.

Preliminary to the joint session, a paper was presented by Mr. O. B. Blackwell discussing the technical problems involved in transatlantic telephony. Following Mr. Blackwell's remarks, Mr. K. W. Waterson outlined the operating problem of this service. Both of these papers will appear in a future issue of the JOURNAL. At the close of Mr. Waterson's address, President Gherardi called upon Mr. Charlesworth to say a few words in regard to the meeting in London and to arrange for the joint session.

MR. CHARLESWORTH: Mr. President, Members and Guests: Before proceeding with the joint session with our associates in the British Institution of Electrical Engineers, I wish to say just a few words concerning their London meeting in order to help you to visualize the nature and significance of our joint session.

Our British associates are assembled in the auditorium of the Institution of Electrical Engineers Building located on the Victorian Embankment. The time is about three-thirty in the afternoon. Their meeting includes their President, Archibald Page, Chief Engineer of Central Electricity Board, their Vice-President, Colonel Purves, Engineer in Chief of the British Post Office, the full Council of the Institution, members, and invited guests from all parts of Great Britain, men prominent in all branches of the electrical industry. As in the case of our own meeting here, a separate auditorium has been equipped with loudspeakers to provide for an overflow meeting. The same film which you saw earlier this morning has been shown.

Through the medium of developments which have been made in electrical communication, we are in effect to wipe out the great distance which separates the meeting places of our two societies, and to come together in a joint session in which our respective Presidents may exchange greetings in our behalf and in which other distinguished representatives of our two societies may take part. By means of the loudspeakers, we shall all be able to hear these proceedings as though we were all located in one great auditorium.

In order that you may further visualize the proceedings taking place in London and those who will address us, I shall ask that their pictures be thrown on the screen. (At this point portraits of Mr. Archibald Page, Colonel Purves and Sir Oliver Lodge were shown.)

Colonel Purves has just finished making a statement to his associates concerning our meeting here in New York.

I shall now speak to Colonel Lee, who is at the telephone in London, and we shall than proceed with our joint session.

Good morning, Colonel Lee.

COLONEL LEE: Good afternoon, Mr. Charlesworth.

MR. CHARLESWORTH: Are we ready to proceed with our joint session, Colonel Lee?

COLONEL LEE: We are, Mr. Charlesworth.

MR. CHARLESWORTH: I shall hand the telephone to Mr. Bancroft Gherardi, President of the American Institute of Electrical Engineers.

COLONEL LEE: I shall also hand the telephone to Mr. Archibald Page, President of the British Institution of Electrical Engineers.

MR. GHERARDI: Good morning, Mr. Page.

MR. PAGE: Good afternoon, Mr. Gherardi.

MR. GHERARDI: Mr. Page, it would give us the greatest pleasure and satisfaction if, as the President of the Institution of Electrical Engineers which was founded in 1871, thirteen years before the founding of our Institute here, you would act as Chairman of this joint meeting.

CHAIRMAN PAGE: Thank you, Mr. Gherardi. I regard it as a great honor to be asked to take the chair on this historic occasion. It is also a gracious compliment to our Institution, and in accepting, which I do gladly, I desire to thank you, Mr. President, and the members of the American Institute of Electrical Engineers most heartily. I welcome all present at the meeting now in session, and venture to predict that the proceedings will prove exceedingly interesting and likely to live not only in our memories, but to be quoted by succeeding generations of electrical engineers as marking an important milestone in the advancement of electrical science. I am sure I interpret the desire of those assembled if I request Mr. Gheradi to address us, which I now do.

MR. GHERARDI: Mr. President and Members of the Institution of Electrical Engineers: On behalf of the American Institute of Electrical Engineers, I extend to you greetings and our best wishes.

We are meeting here in New York at our Winter Convention. In the auditorium of the Engineering Societies Building in New York City, from which I am speaking, there are assembled about one thousand members of our organization from all parts of the United States, from Canada, and from other parts of the New World. Arrangements have also been made for an overflow meeting and several hundred are there assembled, and, by means of the loudspeakers, are able to hear all that takes place at these proceedings.

It is with the greatest satisfaction that, as a result of the accumulated work of the scientist, the inventor, and the electrical engineer, it is possible for us to hold this joint meeting—the first of its kind. It is with feelings of deep appreciation and respect that we think of the men who have exemplified the ideals of your organization—Faraday, Maxwell, Kelvin,—and of the many others, past and present, who have contributed to electrical engineering and to the scientific foundations upon which it rests. These developments have been notable and have contributed in the greatest degree to the welfare of mankind. One of these developments is the art of electrical communication—the electric telegraph and the telephone. These have made communication independent of transportation and no longer subject to all of its difficulties and delays. By the telephone, distance has not only been annihilated, but communication by means of the spoken word has become possible. Starting in 1876 with instruments and lines which with difficulty permitted communication over distances limited to a few miles, the telephone art has been improved year by year until continents have been spanned and at last even the limitations of the Atlantic Ocean have been overcome, and today telephone conversation between the two great capitals of the English-speaking world is a reality. We are gratified that transatlantic communication has made this meeting possible; it has added one more to the many ties existing between our two institutions and has added still another opportunity for friendly communication between us.

CHAIRMAN PAGE: Mr. Gherardi and Gentlemen: (I should add also Ladies, as we have a few of the fair sex with us here in London this afternoon) Please regard me for the time being, not as Chairman but rather as representing the thirteen thousand members of the Institution of Electrical Engineers. My first desire is to thank you, sir, for your most kind message of good-will to us all. In turn, we hail the President and members of the American Institute of Electrical Engineers with feelings of the utmost warmth and of everything included in the term good comradeship.

Owing to the hour at which it has been necessary to hold this meeting falling within the period when the bulk of our members have to be on duty elsewhere, we have perforce had to content ourselves with a smaller gathering in London than that composing your convention. It is, however, of a thoroughly representative

character, consisting of specially invited distinguished guests, the Council of the Institution, many of whom have traveled long distances to be present, and a large percentage of the members of our wireless section.

The telephone must rank as one of the greatest inventions of the nineteenth century and it has transformed the daily life of all civilized people. Our indebtedness to Graham Bell for the boon he has conferred upon us increases with the years, and his memory, along with that of Franklin and Henry, will be cherished as becomes such benefactors of mankind. It would indeed be a gigantic task to attempt to exhaust the list of those of your society who have contributed so largely to the progress of electrical science, and I must content myself by paying tribute to a great institution which has given proof time and again that engineering is truly international. It cannot be questioned that we are living in a period of extraordinary change due to scientific discovery, and in no field has the advance been more marked than in that of the communication engineering. The commercial radio services thus placed at our disposal assure closer and closer association between the English-speaking races, new spice is added to life and bonds of friendship materially strengthened. I rejoice that our two institutions can combine in the future even more effectively than in the past and that this is the outcome of the splendid work done in one of the branches of our own profession.

I shall now resume my chairmanship and call upon Dr. Jewett to speak.

Dr. F. B. Jewett: Mr. Chairman, Mr. Gherardi, and fellow members of the Institution of Electrical Engineers and of the American Institute of Electrical Engineers: The opportunity which this occasion offers of addressing jointly two widely separated groups of engineers who, in times past, I have addressed vis-a-vis, in London and New York, affords me the liveliest satisfaction.

I am gratified to participate in an event which marks both a notable advance in electrical communication and a pioneer demonstration of a wider use for electrical communication.

I am frankly pleased that in common with numerous associates on both sides of the Atlantic, it has been my good fortune to play a part in the development work which has made this occasion possible.

Colonel Purves and Mr. Gherardi will remember, and the rest of you will be interested to know, that in London, more than a year ago when we were engaged in final considerations preliminary to the opening of commercial transatlantic telephony, we discussed the details of just such a meeting as this. That our discussion should have been serious and not a pleasant mental diversion at a time when the channels of communication were not in operation is a striking evidence of the sound basis which underlies present-day electrical engineering. The fact that we saw and appraised the many obstacles to be overcome did not in the least diminish the assurance with which we talked of and planned for a distant event.

While, therefore, the present occasion is highly gratifying to the engineers whose work had made it possible, it is in no sense a surprise.

The success of this occasion is significant also in that it is the tangible evidence of a cooperation both intimate and full between men so situated as to make cooperation difficult. On behalf of my associates in America, I salute our associates in England.

Transatlantic Convention—President of the A. I. E. E. Addressing the I. E. E. in London by Radio. Left to Right: Standing, K. W. Waterson, O. B. Blackwell and President Gherardi; Seated, H. P. Charlesworth, Gen. John J. Carty and Dr. F. B. Jewett

Chairman Page: I have now great pleasure in calling upon Colonel Purves, Vice-President of the Institution of Electrical Engineers, and Engineer-in-Chief of the British Post Office.

Colonel Purves: Mr. President, Mr. Gherardi, Dr. Jewett and Gentlemen: It is an honor and a privilege to be associated with this notable event, which one can justly feel is breaking new ground in the advance of nations towards closer relationship. It is a great thing that two large assemblies separated by wide expanses of ocean can join together as we are doing now, and interchange their thoughts and ideas by the simple and natural medium of direct speech to a combined audience. It opens up the prospects of results which thrill the imagination, and which are bound to be beneficient, and to conduce, by the way of clearer and mutual understanding, to the good of mankind.

On this first occasion it is inevitable to the many professional interests which our two institutions share and which we should dearly like to talk over with each other should be pushed a little into the background, and that we should find ourselves preoccu-

pied mainly with the wonder of the thing itself. At our meeting here in London, we have just been shown a motion picture which illustrates in a very vivid and interesting way the initiation and progress of a transatlantic telephone conversation between San Francisco on the Pacific Ocean and Plymouth in Old England. We were not yet able to place it simultaneously before the eyes of you who are sitting there in New York, but some of you, at least, have seen it already. The greater part of it was made on your side, and I have to thank your President very heartily for letting us have the completed film. It helps one to recall and to visualize the remarkable series of new electrical developments, most of those things of only yesterday, which have combined to make this event possible. The radio art has given us its essential basic principles and the high power amplifying tubes, which over here we call valves. Long distance telephony has contributed a host of new devices which are equally essential. Specialized broadcast has given us the loud speaking receiver. As we sit and talk to each other our speech is launched into the air by the radio transmitting stations at Rugby and at Rocky Point with an electric-magnetic wave energy of more than two hundred horsepower, and I may add, the combined effect of the various refinements and special devices included in the transmitting and receiving systems is to make the speech efficiency of each unit of this power many thousands of times greater than that of an equivalent amount of power radiated by an ordinary broadcasting station. Many further improvements are being studied.

I should like to express the feelings of great personal pleasure with which I am listening to the voices of my old and valued friends of the American Telephone and Telegraph Company, Mr. Gherardi, Dr. Jewett and General Carty, and to assure them and their colleagues both on my own behalf and on behalf of the engineering staff of the British Post Office, that the increased opportunities of cooperation with them which the development of the transatlantic telephone system has afforded us, are appreciated in a very high degree. We have to thank them for much helpful counsel in this and in many other matters and we look forward with great pleasure to a continuance of our close association with them on the long road forward, over which we still have to travel together.

Chairman Page: We are delighted to have with us in New York General John J. Carty, Vice-President of the American Telephone and Telegraph Company and Past-President of the American Institute of Electrical Engineers. It gives me great pleasure indeed to have this opportunity to congratulate General Carty on the presentation which he received last evening, of the John Fritz Medal. This was presented to him by the National Engineering Societies of the United States for his outstanding achievements in the engineering field. General Carty is widely regarded as the doyen, or to be more correct, the dean of the telephone engineering profession, and we shall be glad if he will say a few words and propose a resolution on the subject of our joint meeting.

General John J. Carty: Mr. Chairman, I wish to thank you most sincerely for your very kind references to me and to the medal which it was my privilege to receive last night.

The deep significance and very great importance of this meeting which is being held today is appreciated by all of our members present, who are gathered from all parts of the United States. The far-reaching effect of this meeting in strengthening the already powerful bonds which unite the two societies will be hard to forget. I know that I express the deep feeling of all present when I say how greatly we are impressed with the eloquent speeches which we have heard from our London colleagues, and as I could not add anything to what has already been said, I should like to have the privilege of offering the following resolution:

Whereas, On this sixteenth day of February, 1928, the members of the Institution of Electrical Engineers assembled in London, and the members of the American Institute of Electrical Engineers assembled in New York, have held, through the instrumentality of the transatlantic telephone, a joint meeting at which those in attendance in both cities were able to participate in the proceedings and hear all that was said, although the two gatherings were separated by the Atlantic Ocean; and as this meeting, the first of its kind, has been rendered possible by engineering developments in the application of electricity to communication by telephone; therefore,

Be It Resolved, That this meeting wishes to express its feelings of deep satisfaction that, by the electrical transmission of the spoken word, these two national societies have been brought together in this new form of international assembly, which should prove to be a powerful agency in the increase of good-will and understanding among the nations; and

Be It Further Resolved, That a record of this epoch-making event be inscribed in the minutes of each society.

This is the end of my resolution, Mr. Chairman.

Chairman Page: Sir Oliver Lodge, who needs no introduction, is sitting beside me, and I have asked him to second the motion.

Sir Oliver Lodge: Mr. Chairman, I think it very kind of you and the Council to allow me to take part in this important occasion, to send greetings to our many American friends.

It is surely right and fitting that a record of the transmission of human speech across the Atlantic be placed upon the minutes of those societies whose members have been most instrumental in making such an achievement possible, and I second the proposal that has been just made from America.

All those who in any degree have contributed to such a result, from Maxwell and Hertz downwards, including all past members of the old British Society of Telegraph Engineers, will rejoice, at this further development of the power of long distance communication. Many causes have contributed to make it possible. That speech is transmissible at all is due to the invention of the telephone. That speech can be transmitted by ether waves is due to the invention of the valve and the harnessing of electrons for that purpose. That ether waves are constrained by the atmosphere to follow the curvature of the earth's surface is an unexpected bonus on the part of Providence, such as is sometimes vouchsafed in furtherance of human effort. The actual achievement of today at which we rejoice and which posterity will utilize must be credited to the enthusiastic cooperation owing to the scientific and engineering skill of many workers in the background whose names are not familiar to the public as well as to those who are well known.

The union and permanent friendliness of all branches of the English-speaking race, now let us hope more firmly established than ever, is an asset of incalculable value to the whole humanity. Let no words of hostility be ever spoken.

Chairman Page: Gentlemen, you have heard the motion proposed by General Carty and seconded by Sir Oliver Lodge. I now put it to the joint meeting. Those in favor say "aye." (Response of "ayes" clearly heard by all.) "Contrary. (Dead silence.) It is carried unanimously.

I suggest, Mr. Gherardi, that we now adjourn the meeting. I feel that it has been eminently successful and that we should regard it as the forerunner of many more to come.

Mr. Gherardi: Mr. Page, before you adjourn the meeting, I should like to take this opportunity to thank you for the gracious manner in which you have acted as Chairman of this meeting, the first of its kind that ever has been held. We, on this side, send you our good-bye greetings and consent to the adjournment of the meeting.

Chairman Page: President Gherardi, I am exceedingly obliged to you for the kind words which you have just spoken.

That is all the business, gentlemen. The meeting is now adjourned. Good-bye New York.

Medal Presentations

Edison Medal

One of the most impressive and enjoyable functions of the Winter Convention was the dual medal presentations which took place on Wednesday evening, February 15th. The ceremonies were witnessed by an audience that filled the Engineering Auditorium to capacity, and seated on the platform were many of the well-known leaders in the engineering profession, several of them former Edison medalists. The presentation of the Edison Medal to Dr. W. D. Coolidge was followed by the presentation of the John Fritz Medal to General John J. Carty, Bancroft Gherardi, President of the A. I. E. E. presided during the first ceremony.

President Gherardi spoke as follows:

There is a happy combination of sentiment and justice in this occasion when their merits call us together to bestow the marks of our esteem upon the same men that we equally delight to honor with our affection.

There are no higher awards which can be made by engineers to fellow engineers than the medals which are to be presented this evening. The Edison Medal was founded by a group of the associates and friends of Thomas A. Edison to commemorate the achievements of a quarter of a century in the art of electrical engineering with which Edison had been so prominently identified. To this end, the group established a gold medal which could serve in the words of the deed of gift, "as an honorable incentive to scientists, engineers and artisans to maintain by their works the high standard of accomplishment set by the illustrious man by whose name the medal is known." The award is made by the American Institute of Electrical Engineers acting through its Edison Medal Committee composed of twenty-four members. But one award is made each year and the deed of gift specifies that it shall be to someone resident in the United States or Canada for meritorious achievement in electrical science, electrical engineering or the electric arts. The first award was made in 1909 to Dr. Elihu Thomson and we are honored by his presence this evening. Among the others to whom the medal has been awarded are: Dr. Sprague, General Carty, Dr. Pupin, Mr. Chesney and Dr. Lieb, who are with us this evening. By unanimous action of the Edison Medal Committee in December of last year, the medal was awarded to William D. Coolidge and I now have the pleasure of calling upon Dr. Michael Pupin, Chairman of the Edison Medal Committee, a past President of the American Institute of Electrical Engineers, a distinguished scientist, educator, author and inventor, and the Edison Medalist of 1920, to tell us of the achievements of Dr. Coolidge.

Dr. Pupin in alluding to the achievements of Dr. Coolidge called attention to the wonderful results of physics and its engineering branches which form a permanent exhibit in New York and all the large cities of the world. The electric lighting, subways and telephone systems are only a part of this permanent exhibition of engineering and the whole terrestrial globe is their exhibition ground. Continuing, he said:

This evening we are honoring two men who have many wonderful exhibits in this permanent exhibition of the science of physics and of its engineering branches. These exhibits are so universally known and appreciated that they need no specially prepared explanatory and eulogistic catalogue. This occasion calls for some illustrations. I shall describe some of them; President Gherardi will describe several others.

The science and the art of incandescent lighting are as perfect as human ingenuity can make them; in every nook and corner of our daily life they are as familiar as our daily bread. Fifty years ago Edison became their happy father; this evening he is rejoicing that his medal of honor will be conferred upon a man who has contributed a giant share to the bringing up of his favorite children. Who can look upon the heavenly light of the tungsten filament or listen to the eloquence of the radio tube without blessing the name of the man whom we are decorating this evening with the Edison Medal?

Many of us remember still the vagaries of the X-ray tube of thirty-two years ago. Today it is an instrument of precision that can be handled with ease by the most awkward medical practitioner. It is fool-proof. This instrument of precision created by the acumen of the man whom we are honoring this evening has brought relief to millions of suffering human beings. The magic of his cathode tube is driving into the atmosphere a countless host of electrons running a close race with a beam of light. They will make radium blush with envy and will perhaps unlock nature's treasures where many a precious secret awaits the guiding genius of man.

The story of his achievements is much longer, but what I have already said explains sufficiently the homage which we are paying to him this evening.

When Lindbergh landed in Paris he said to the waiting crowd: "My name is Charles Lindbergh." His name had traveled ahead of him and its simple announcement thrilled the crowd as it was never thrilled before. A similar thrill is in store for us this evening. The fame of the Edison medalist for 1927 has been in our minds for many years, and he will now step before you and announce! I am William D. Coolidge.

At the conclusion of Dr. Pupin's remarks President Gherardi presented the Edison Medal and certificate of award to Dr. Coolidge "for his contributions to the incandescent lighting and the X-ray arts."

In responding, Dr. Coolidge said:

Allow me to express my keen appreciation of the great honor which you have conferred upon me. I take an added pleasure in the possession of the Edison Medal because of the fact that so much of my work has been done in fields first plowed by Mr. Edison.

I wish to thank Dr. Pupin for all of the nice things which he has said about me and about the work on which the award was based. Let me hasten to add, however, that I couldn't possibly accept them for myself alone, but must share them with many others, without whose assistance the work could not have been done.

Foremost among these let me mention Dr. W. R. Whitney, to whose vision, optimism, courage, unselfishness and high ideals we owe both the form and the spirit of our research organization.

Next I must mention Dr. E. W. Rice, Jr., and Mr. A. G. Davis, both of whom were always ready with active sympathy and wise counsel.

Then I must pay my tribute to Mr. George F. Morrison and Mr. John W. Howell, who brought to us the hearty cooperation of our incandescent lamp organization.

In the medical X-ray field, we owe much to the many Roentgenologists whose close cooperation with us made possible the development of tools adapted to their needs.

To those already mentioned I must add the entire staff of our research organization, almost every one of whom contributed something.

Allow me, then, as spokesman for all these, to thank you, Mr. President, and the American Institute of Electrical Engineers for your generous recognition of our work and for this beautiful symbol of that recognition.

Dr. Coolidge then gave a short address on the "Use of Very High Voltage in Vacuum Tubes" which is printed on page 212 of this issue.

John Fritz Medal

The presentation of the John Fritz medal to General John J. Carty at the Winter Convention of the A. I. E. E. followed immediately after the Edison Medal presentation on Wednesday, February 15th. Mr. J. V. W. Reynders, Chairman of the Board of Award, occupied the chair and addressed the meeting as follows:

Let me first of all on behalf of the Board of Award of the John Fritz Medal express our appreciation of the hospitality that is being extended to us on this occasion by the American Institute of Electrical Engineers. It is a happy occasion when the Founders' Societies are enabled to meet as they do on this occasion and to find themselves in close contact and to also find themselves in the position for closer cooperation.

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As we contemplate the bestowal of the John Fritz Medal year after year on men of wide-world distinction in the various fields of engineering, men who in one way or another have given impulse and direction to the progress of mankind, the question becomes interesting as to what manner of man was John Fritz and what were the qualities that singled out his name to be so conspicuously associated with the world's great scientific and industrial achievements.

If, as Lowell said, it is the duty of the nation to produce great men, our country surely rose to her opportunity when she guided and guarded the career of John Fritz. Starting life as a blacksmith with no advantages of education, without influential friends or the favoring accidents of fortune, he advanced steadily in usefulness, power and respect of his fellow-men until by common consent he occupied the first place in the domain of the steel industry of this country. The numerous honorary scientific memberships conferred upon him in this country and abroad attest the esteem in which he is held by his fellow engineers. Twenty years after his retirement from active business at the age of seventy, he lived to enjoy, as few men have been permitted to do, the fame and the friendships which he had so amply earned. His sterner qualities of industry, integrity and sterling character were relieved by unfailing human sympathy, humor and spontaneous good-will toward his fellow men. To all who worked with John Fritz, he was known as the "old man," that unmistakable title of leadership.

More than a quarter of a century has elapsed since that memorable occasion when the medal we are here gathered to confer was first instituted. I have given you a few abbreviated quotations only from the notable speeches that were delivered on that occasion. It was but natural under-

the circumstances that referencesh ould be made to the remarkable changes which occurred during the active lifetime of John Fritz, the transition from wrought iron to Bessemer steel, making possible the extension of transcontinental railway systems, the change from Bessemer to open hearth steel, which transformed steel making from a melting to a refining operation, and so forth.

* * * * * *

Professor Elihu Thompson was the representative of electrical engineering who spoke at the John Fritz dinner of 1902. He then inquired in what direction did America lead the world first. In electrical engineering. Then after referring to the enormous growth and development of the electrical field, he graciously acknowledged that in the end it all leads back to the iron master. He demonstrated how electrical science had revolutionized lighting, power, industry, transportation, and even metallurgy. He dimly foresees the possibilities of wireless transmission in these words: "Now we are, as it were, on the threshhold of this development. Within a few years we have had a most surprising development in the way of transmission of signals for long distances. We have seized upon an atmosphere not of air but of that something which is within the air and which fills all space and makes it the means of communication."

To have attempted to prophesy beyond such guarded limits would have risked one's reputation for sound judgment, and yet we are faced with accomplished facts which are probably unprecedented in the application of scientific research to practise. Of all the revolutionary changes that electricity has brought about, none has been so effective in changing our manner and speed of conducting every activity of human existence as the developments in the field of telephony. It is not my purpose, nor is it in my province to anticipate those that are to follow, beyond a brief allusion beyond that unrivaled example which is comprised in the American telephone system. Unconsciously we pay a tribute to its perfection when we display irritation if we fail to get our connection inside of the space of thirty seconds.

Dr. Jewett, in the course of the discussion of our Board, outlined the policy prescribed by the recipient of this year's John Fritz Medal at a time when telephony was yet in the state of chaos. Long before the present state of communication could be foreseen, General Carty outlined as the dominant rule that all new construction must be carried out in a manner that presupposed the ability ultimately to connect every user anywhere with any other user throughout the territory of the United States. This implied as a prerequisite uniformity in all matters affecting not only equipment, including the various elements of power, motors, dynamos, batteries, and so forth, but also uniform practise in operation such as the maintenance of constant voltages between limits. These considerations, obvious as they may seem as an accomplished fact, involve conviction born of large vision and willingness to make large financial sacrifices to insure the ultimate end. The results of General Carty's vision constitute one of our great national assets contributing as no other single instrumentality has done to the effectiveness of our national enterprise. What he has accomplished on such a broad and liberal scale is a source of pride to all Americans and above all to his fellow engineers.

The names of former recipients of the John Fritz Medal in the electrical field include those of Kelvin, Bell, Edison, Thompson, Marconi and Adams. It is a grateful privilege to be able to add to this distinguished list on behalf of my fellow members of the Board of Award and of the engineering profession which they represent, the name of General John J. Carty.

Chairman Reynders then called upon Bancroft Gherardi, who had been associated with the medalist for 33 years, to tell something of General Carty's accomplishment in the development of the telephone industry. Mr. Gherardi responded as follows:

In 1879, only three years after Alexander Graham Bell had first publicly demonstrated his telephone invention, a young man eighteen years of age who had prepared for Harvard but was prevented from continuing scholastic work by temporary impairment of his eyesight, entered the employ of the Bell Telephone Company in Boston.

It is difficult, if not impossible, for any of us now to visualize the telephone problem of that time and the conditions under which it had to be approached by the telephone pioneers of that day. Much of our scientific knowledge of today had not been discovered; there were no schools of electrical engineering to provide trained personnel; the American Institute of Electrical Engineers was not to be founded until five years later; there were no sources of electrical energy except primary batteries and magneto generators; no adequate theories of the transmission of electric currents over wires; no commercial applications of electricity except the electric telegraph and the infant telephone art. At that time there were in the whole of these United States fewer telephones than are to be found today in East Orange, and it was impossible to talk over distances greater than a few miles.

Practically nothing had been done and few of the essentials to the attainment of our present telephone system were known. But there was a small group of men of vision and of courage, confident of the possibilities of the telephone and determined that it should attain the future that they saw for it in their dreams. One of these was John J. Carty.

To tell the story of his life and of his contributions is to tell a very large part of the scientific, technical and engineering development of the telephone art, not only in this country but for the whole world. After early experience in the design, construction, maintenance and operation of telephone systems in and around Boston and with the Western Electric Company in New York City, Carty in 1889 became the Chief Engineer of the New York Telephone Company. In that position he was responsible for the technical problems of the city which is telephonically the greatest in the world and where new problems are most likely to arise. In 1907 he became Chief Engineer of the American Telephone & Telegraph Company, the parent company of the Bell System. At the outbreak of the War he was ordered to active duty as a Major in the Signal Corps of the United States Army. He saw active service in France and rapidly rose to the rank of Brigadier General. Since his return from France in 1919 he has been Vice President of the American Telephone & Telegraph Company. These, briefly, are the positions which he has held: What did he do with the opportunities which they offered?

His personal contributions to the telephone art have been notable. He designed and itstalled the first multiple switchboard which contained the fundamental features of common battery signaling, and later was the first to show how to operate two or more telephone transmitters from a single source of electric supply. These together constitute the foundation of the common battery system of today essential to every large telephone switchboard, whether automatic or manual.

From the start of the telephone business one of the difficulties which had to be met was to prevent induction between closely adjacent telephone circuits, the result of which would be that speech taking place in any one of the circuits could be overheard in all. Closely related to this problem has been that of minimizing external inductive disturbances—those that come from electric currents in other than telephone circuits, and from atmospheric or earth currents. At a time when but little was known on these subjects, Carty made an important scientific investigation of their nature and set forth the view that under many conditions these disturbances were electrostatic and not electromagnetic in character. This view was so novel that it was not generally accepted until it had been checked and verified by others, but it was soon recognized as correct and served as a guide to much essential work in the minimizing of these disturbances. This work of Carty's made it possible to give scientific treatment to the twisted-pair and transposition problems and laid the foundation for the keeping of inductive disturbances within limits that permitted the development of the industry.

Early telephone systems followed the usual telegraph practise of placing telephone instruments, including the signaling devices, in series in the line. The result of this arrangement—when there were several instruments on the same line—was to impair telephone transmission seriously and to interfere with satisfactory signaling. It placed severe limitations upon the number of telephones which might be connected to a single line. Carty's scientific study of this question led him to the conclusion that the instruments should be placed in parallel and not in series, and should be re-designed so that the signaling apparatus would have high impedance. This invention is commonly known as "Carty's bridging bell." It removed many of the difficulties which had formerly imposed serious limitations on the development of the business, and made the party line and the rural subscriber's line a possibility.

Carty prepared the plans and immediately directed the work of converting the New York City telephone plant from open wire to cable, and later from the local battery switchboard system to the common battery system, at a time when the general development of the art was such that almost every move required invention, development and engineering along new lines.

If we were to take out of the present telephone system those things—a few only of which I have mentioned—which John J. Carty personally devised and contributed to the art, essential elements would have been removed and in many important respects the system would no longer be operative. This is some measure of Carty's individual achievements.

But he had qualities not always found in men of individual creative genius. He had the rare ability to organize progress as well as to contribute to it himself. As the telephone system grew and its problems multiplied in number and complexity, Carty early recognized that the work to be done required the development of a technical organization, and he was first in the telephone operating companies to employ technically-trained college graduates and to devote systematic attention to their training both in a thorough knowledge of the telephone system and in the correct principles of engineering.

No one who has ever worked in close cooperation with Carty for any considerable length of time can forget the frequency with which he asked the question "What are the facts?" and the emphasis which he laid on it, or the importance that he attached to studying all possible solutions of a problem and ascertaining which was the best, taking into account all relevant factors including first cost, annual charges, service, and flexibility and adaptability to growth and expansion.

He recognized the inter-relationship in the telephone business of operating methods, the design of the plant, the rate structure which would largely determine the volume and character of the telephones to be served if the system was to give the best possible, the most extended, and the cheapest telephone service. He had in mind that all of these factors must be considered in their relations one to the other and their relation to the final result. Always was his engineering dominated by this consideration for the final result, not alone immediately but for the years ahead.

His methods not only developed telephone systems and service along

sound and effective lines, but he has always been a great developer of people. He inspired them to give the best that was in them; he taught them to do better; and was always lenient to their shortcomings, and both constructive and kindly in criticism. His influence on others extended far beyond those working directly for him. All who had contact with him felt the power of his keen analytical mind, his breadth of vision, his sense of justice, and his kindly disposition.

The nature of Carty's early contributions to the telephone art showed his clear appreciation of the importance of scientific knowledge to the understanding of telephone problems. When he became Chief Engineer of the American Telephone & Telegraph Company in 1907 he was in a position to do so and he immediately consolidated all of the telephone laboratories and experimental work, which up to that time had been scattered both as to location and executive control, into a single organization, which is now known as the Bell Telephone Laboratories. He greatly increased the number of scientists engaged upon this work. Of the many fundamental contributions which have resulted from this arrangement, I shall mention but two. He initiated and pushed to a successful conclusion the work necessary to make transcontinental telephony possible. Through its applications, telephone service has been extended to tie together not only every state of our Union, but to bring into the range of telephonic communication Canada, Cuba and Mexico. He likewise inspired and directed the work which resulted in the sending of the first articulate words across the Atlantic Ocean by radio telephony, and continued this work until today the barrier of the Atlantic Ocean has been overcome and commercial telephone service between the old world and the new is a daily fact. Already four nations of the new world can communicate telephonically with Great Britain and four nations of the Continent of Europe, and it is not too much to believe that through the further extension of these developments all of the principal nations of the world may be brought into communication by the spoken word.

This organization of research and development was not only a service to the telephone art; it was a notable contribution to our present-day American civilization, for the organization of science to lead industrial progress now common in many industries received a tremendous impetus from Carty's work in the organization of the laboratories of the Bell System and in the obvious value of its accomplishments. It is in recognition of Carty's vision and achievements along these lines that he is a trustee of the Carnegie Institution and of the Carnegie Foundation, a trustee of New York University, a member of the National Research Council, and associated with other organizations whose object is the advancement of science and the applying of these advances to the welfare of mankind.

Until 1917 Carty's genius was devoted to the arts of peace. Then our country was plunged into the World War and it became the duty of every American citizen and organization to contribute their all to the successful outcome of the War. Recognizing the importance of communication and Carty's pre-eminent position in relation thereto, our Government which had previously commissioned him a Major in the Reserve Signal Corps of the Army ordered him to active duty. He devoted to the Signal Corps problem that same judgment, skill and knowledge which had produced such outstanding results in civil life, and largely through his efforts the resources of the nation's telephone personnel, laboratories, manufactures and supplies were brought to bear upon the problems of the War and in such a way as not to cripple the communication on the home front which must also continue to function. In June 1918 he was ordered to France where he was one of the principal staff officers of the Chief Signal Officer of the American Expeditionary Forces. After the Armistice he remained in France for a time in charge of the communications of the American Commission to negotiate peace. In recognition of his services in the Army he received from our Government the Distinguished Service Medal and from France the Cross of the Legion of Honor.

General John J. Carty, who comes to us this evening in order that we may bestow upon him a token of the appreciation in which his distinguished achievements are held by his fellow engineers represented by the four national engineering societies, is—

The creator of telephone engineering;

The discoverer or inventor of many essential methods and devices;

The organizer and director for many years of the Bell System technical and engineering work;

The father of the application of scientific research to the telephone art;

The director of the development of transcontinental and transoceanic telephony;

A pioneer in advocating scientific research in industry;

A leader in the application of the developments of electrical communication—which he had such an important part in creating—to the national defense in the hour of our country's need;

The dean of telephone engineers.

At the close of Mr. Gherardi's remarks the John Fritz medal and certificate of award were presented to General Carty by Robert Ridgway, chairman of the Board when the award was made, who stated that the John Fritz Medal Board of Award representing the four Founder Societies had by unanimous vote awarded its medal to General Carty "for pioneer achievement in telephone engineering and in the development of scientific research in the telephone art."

General Carty in responding expressed his high appreciation of the honor which was bestowed upon him and gave a highly interesting address on the ideals of the engineer, which is published on page 210 of this issue of the Journal.

A. I. E. E. Directors' Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Thursday, February 16, 1928.

There were present: President Bancroft Gherardi, New York City; Vice-Presidents H. M. Hobart, Schenectady, N. Y.; B. G. Jamieson, Chicago, Ill.; G. L. Knight, Brooklyn, N. Y.; A. E. Bettis, Kansas City, Mo.; O. J. Ferguson, Lincoln, Neb.; E. R. Northmore, Los Angeles, Calif.; J. L. Beaver, Bethlehem, Pa.; A. B. Cooper, Toronto, Ont.; C. O. Bickelhaupt, Atlanta, Ga.; Managers John B. Whitehead, Baltimore, Md.; J. M. Bryant, Austin, Tex.; H. A. Kidder, New York City; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; National Secretary F. L. Hutchinson, New York City.

The minutes of the Directors' meeting of December 16, 1927, were approved.

A minute was adopted in memory of Dr. W. C. L. Eglin, former Manager and Vice-President of the Institute, who died on February 7, 1928.

Reports were presented of meetings of the Board of Examiners held January 18 and February 8, 1928; and upon the recommendation of the Board of Examiners the following actions were taken: 297 applicants were elected to the grade of Associate; 9 applicants were elected to the grade of Member; 29 applicants were transferred to the grade of Member; 3 applicants were transferred to the grade of Fellow.

The Board ratified approval by the Finance Committee for payment, of monthly bills amounting to $27,277.23.

In accordance with Section 22 of the Constitution, the following were made "Members for Life" by remission of future dues: Henry W. Blake, H. Doyer, A. L. Rohrer, Charles F. Scott, and I. E. Winslow.

Approval by the Executive Committee of proposed constitutional amendments for submission to the membership for letter ballot, was ratified.

Approval was given to the suggestion that arrangements be made with a tourist agency to conduct a trip for members and guests of the Institute from points in the eastern part of the United States, and along the route, to the 1928 Summer Convention in Denver, June 25-29, followed by a trip through the Yellowstone Park.

Consideration was given to a suggested form of combined annual report of Sections and Branches, which was approved for printing and distribution prior to the Section Delegates' Conference, at Denver, in June.

Authorization was given for the affiliation of Brown Engineering Society, a student engineering society of Brown University, as an "Affiliated Society," in accordance with Section 59A of the Institute by-laws.

In accordance with recommendations of the Standards Committee, the following actions were taken:

Decided to take no action on communications received advocating the adoption of a revised calendar of thirteen months of twenty-eight days each;

Authorized the cancellation of the definition of the word "substation" in the present Standards, inasmuch as the present definition as applied to the traction art is apparently not comprehensive of the commonly and properly understood meaning of the word "substation," and pending the report of a subcommittee which is working on a series of definitions of "substation" as an exposition of the understanding of the word in different fields;

Approved as an Institute Standards, revised Standards for Storage Batteries (No. 36); and

Approved material prepared by the Power Generation Committee for inclusion in the A. S. M. E. Test Codes.

Approval was given to a report of the Special Committee on Lamme Medal, which included approval of the obverse of the medal and execution of agreement with the sculptor.

The following Institute representatives on the U. S. National Committee of the International Electrotechnical Commission were appointed, to serve until the next Plenary Meeting of the I. E. C.: Messrs. E. W. Allen, L. W. Chubb, W. A. Del Mar, Gano Dunn, B. Gherardi, H. M. Hobart, D. C. Jackson, F. B. Jewett, A. E. Kennelly, H. A. Kidder, J. W. Lieb, F. V. Magalhaes, C. O. Mailloux, William McClellan, E. B. Meyer, J. F. Meyer, F. D. Newbury, H. S. Osborne, Farley Osgood, F. W. Peek, E. W. Rice, Jr., L. T. Robinson, D. W. Roper, C. H. Sharp, C. E. Skinner, W. I. Slichter, A. R. Stevenson, Jr., N. W. Storer, and Elihu Thomson.

Upon request, the Board approved the admission to membership in the American Engineering Standards Committee of the Automatic Sprinkler Association, and independent membership of the American Gas Association.

The President was authorized to appoint representatives of the Institute to attend the dedication ceremonies of the Louvain Memorial, July 4, 1928.

Other matters of importance were discussed, reference to which may be found in this and future issues of the JOURNAL.

The Louvain Memorial

On 4th July 1928, 48 gold stars will shine in the four clock dials of the new Louvain Library and from its belfry the 48 bells in its carillon representing engineers in each of our 48 states and territories will vibrate the music of America, as well as that of Belgium and other countries, in memory of the hundreds of engineers of the United States who gave their lives in the Great War for the defense of freedom 1914-1918.

The memorial library building given by the Americans, and the Engineers' Memorial clock and carillon, will be dedicated with impressive ceremonies on Independence Day. All engineers from the United States who expect to be in Europe next summer are urged to plan their travels so as to be in Louvain to participate in the dedication. There are available steamers direct to Antwerp and by other routes.

One party is planning to go on the *Lapland* (Red Star Line) sailing from New York June 23 and due in Antwerp 2nd July, returning from Antwerp July 6th and from Southampton July 7th, due in New York July 15th. Passage should be engaged without delay. Address Mr. V. C. Short, agent of the Red Star Line, at One Broadway, New York, for further information.

For the accommodation of engineers and friends who, for one reason or another, did not find it possible to contribute to the fund before February 1st (the limit set in the first invitation), the time has been extended because the Committee desires the memorial to be as representative as possible. However, early responses will be appreciated, as the Committee plans to record the names of all donors in a beautiful memorial volume to be suitably placed in Louvain Library. Remittances in any amount from one dollar to five thousand, may be sent to United Engineering Society, at 29 West 39th Street, New York.

The Memorial Committee also requests assistance in making as complete as possible its Honor Roll of the Engineers who gave their lives in any service of the United States or its allies in the Great War 1914-1918, overseas, on the seas, or in this country. Lists from regimental or other military or naval veteran organizations are especially desired, together with their contributions to the fund. Arrangements may be made to have names of deceased members recorded in the memorial volume in groups under the names of the organizations. Several such units have already been enrolled and have contributed. Others are invited. Arrangements will be made for additions to the memorial record of all acceptable names received within a reasonable time.

Engineers' Memorial Committee

George W. Fuller, Representing American Society of Civil Engineers; Arthur S. Dwight, Representing American Institute of Mining and Metallurgical Engineers; Charles M. Schwab, Representing American Society of Mechanical Engineers; Arthur W. Berresford, Representing American Institute of Electrical Engineers; George Gibbs, Representing United Engineering Society; Edward Dean Adams, *Chairman*, Representing Engineering Foundation and Engineering Societies Library.

Washington Award Presentation 1928

On Thursday, February 2, the Washington Award for 1928 was presented to Dr. Michael I. Pupin, Past-President of the American Institute of Electrical Engineers, at a banquet held at the Palmer House, Chicago.

The Washington Award, presented annually "to an engineer whose work in some special instance or whose services in general have been noteworthy of merit in promoting public good", is the result of a Foundation formed in 1916 by John W. Alvord, a notable Civil Engineer and a Past-President of the Western Society of Engineers. The award is administered by a commission consisting of 17 members, nine of whom are from the Western Society of Engineers and two members each from the A. S. C E., A. I. M. & M. E., A. S. M. E. and A. I. E. E. The chairman of the 1928 Award Commission is R. F. Schuchardt, member of the Western Society of Engineers and a Fellow of the A. I. E. E.

The Washington Award Commission feels that in honoring Dr. Pupin, it has honored itself as well.

President Gherardi spoke of the life and work of Dr. Pupin, both as an admirer and a co-worker for many years in the commercial development of the loading coil. For Dr. Pupin the award read: "In recognition of preeminent service in advancing human progress through engineering it is conferred in the year 1928 upon Michael Idvorsky Pupin for devotion to Scientific research leading to his inventions which have materially aided the development of long distance telephony and radio broadcasting."

Dr. Pupin's response was, in part, as follows:

"My greatest pleasure in accepting this award is in the hope that it will prove an inspiration to the youth of Serbia and show them what a poor Serbian boy can do in this land of opportunity."

Dr. A. N. Talbot delivered greetings to the recipient from the American Society of Civil Engineers, Dr. William Kelly for the American Institute of Mining and Metallurgical Engineers, John Lyle Harrington for the American Society of Mechanical Engineers, and President Gherardi for the American Institute of Electrical Engineers.

International Illumination Congress

In September 1928 there will be held in America, an International Illumination Congress. Arrangements are being made under the auspices of the Illuminating Engineering Society and the United States National Committee of the International Commission on Illumination. The Congress will be featured by

1. Tour to Points of Lighting Interest in the northeastern part of the country.
2. Attendance at the Annual Convention of the Illuminating Engineering Society at Toronto.
3. Plenary Meeting of the International Commission on Illumination.

The occasion for the Congress is the Plenary Meeting of the International Commission on Illumination. This will be the eighth meeting of the Commission. At the 1927 meeting in Italy, eleven countries were represented by delegations of lighting men. It is expected that at the meeting in America there will be an even more representative attendance.

Proposed Letter Symbols for Electrical Quantities

A special committee of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, for which the Institute is one of the five joint sponsors, has prepared the following tentative list of letter symbols for electrical quantities. The Sectional Committee has definitely limited its field to symbols and abbreviations, specifically excluding definitions.

The Standards Committee of the Institute will issue a revision of the Report on Standard Definitions (No. 2, August 1927) and in that revision of the report will include a revision of Table No. 301, paragraph 3604, on Symbols and Abbreviations (1922 edition of the Institute Standards). This table is omitted in the August 1927, edition of Report No. 2. It is hoped to make the Sectional Committee list and the Standards Committee list in Report No. 2 as nearly identical as possible. The difference will be that the A. I. E. E. list will contain columns headed "Unit" and "Abbreviation for the Unit," which will not appear in the Sectional Committee list.

In the following list of symbols two additional columns giving the 1922 A. I. E. E. symbols and the International Electrotechnical Commission list are included. These columns will not appear in the final drafts of either list.

Criticism and comments are invited, and should be sent to H. E. Farrer, Secretary, Standards Committee, A. I. E. E., 33 West 39th Street, New York, N. Y., or to J. Franklin Meyer, Chairman, Sectional Committee, Bureau of Standards, Washington, D. C.

PROPOSED LETTER SYMBOLS FOR ELECTRICAL QUANTITIES

Name of Quantity	Proposed Symbol	Name and Abbreviation of Unit	Symbols as given by A.I.E.E. (1922)	Symbols as given by I. E. C. No. 27
Admittance	$Y\ y$	mho	$Y\ y$	
Angular frequency Angular velocity	ω	radians per second	$\omega = 2\pi f$.	$\omega = 2\pi K$
Capacitance	C	farad f	C	C
Capacity, electrostatic (see capacitance)	C	farad f microfarad μf	C	C
Conductance	g	mho		G
Conductivity	γ	mho per centimeter mho/cm.	g γ	
Current	I, i	ampere amp.	I, i	I
Current density*	i	ampere per unit area		
Difference of potential, electric (see electromotive force and voltage)	E, e	volt v		
Dielectric constant	ϵ or K		K	ϵ
Dielectric flux	Ψ	coulomb		
Dielectric flux density	D	coulomb per sq. cm.		
Efficiency	η		η	η
Electric potential (see electromotive force and voltage)	E, e	volt v		V
Electrical tension (see electromotive force and voltage)	E, e	volt v	E, e or V, v	
Electromotive force (see also voltage)	E, e	volt v	E, e	E
Electrostatic capacity (see capacitance)	C		C	
Electric intensity*	e	volt per cm.		
Electrostatic flux (see dielectric flux)	ψ		ψ	
Electrostatic flux density (see dielectric flux density)	D		D	D
Energy (see work)	W	foot-pound ft-lb. joule watthour wh. kilowatt-hour kwh.	U or W	W
Flux density, electrostatic (see dielectric flux density)	D		D	B
Flux density, magnetic (see magnetic flux density)	B	gauss	$B\ \mathcal{B}$	B
Frequency	f	cycles per second $\sim$	f	f
Impedance	$Z\ z$	ohm Ω	Z, z	Z
Inductance	L	henry h	L	
Magnetic intensity	H	ampere-turn per in. gilbert per cm. ampere-turn per cm.	H	H
Magnetic flux	Φ	maxwell	$\Phi\ \varphi$	Φ
Magnetic flux density	B	gauss	$B\ \mathcal{B}$	B
Magnetomotive force	$\mathcal{F}$	gilbert ampere-turn	$\mathcal{F}$	ϵ
Mutual inductance	M	henry h millihenry mh.	M	M
Number of conductors or turns	N		N	
Permeability	$\mu\ (=B/H)$		$\mu = B/H$	μ
Permeance	$\mathcal{P}$			
Permittance (see capacitance)	C			
Period	T			T
Permittivity (see dielectric constant)	K or ϵ			
Phase displacement	φ	degree, radian	$\theta\ \varphi$	φ
Power	P, p	watt w kilowatt kw. horsepower hp.	$P. p$	P
Quantity, electric Quantity of electricity	$Q\ q$	coulomb ampere-hour amp-hr.	Q, q	Q
Reactance	$X\ x$	ohm Ω	X, x	X
Resistance	$R\ r$	ohm Ω	R, r	R
Resistivity	ρ	ohm-centimeter ohm-cm.	ρ	ρ
Reluctance	$\mathcal{R}$	oersted		S
Reluctivity	$\nu\ (=1/\mu)$			
Self-inductance	L	henry	L	L
Susceptance	b	mho	b	
Speed of rotation	n	revolution per min. (sec) rpm (s)	n	
Torque	T, D	dyne-centimeter pound-foot lb-ft.		
Voltage	E, e	volt v	E, e or V, v	
Work (see energy)	W	erg foot-pound ft-lb. kilogram-meter kg-m	W	A

*See note 2.

Notes:

1. Where a distinction between maximum, instantaneous and root mean square (effective) values is necessary, E_m, I_m, P_m; e, i, p; and E, I, P are recommended.

2. In accordance with the practise in other branches of engineering, it is recommended that quantities per unit volume, area, length, etc., be represented as far as practicable by lower-case letters corresponding to the capitals which represent the total quantities. This applies only in cases where special symbols for such unit quantities have not already come into general use and where confusion is not considered to be serious. In accordance with this rule i and e are proposed for current density and electric intensity, respectively, in the belief that they will not commonly occur together with the instantaneous alternating current and voltage (note 1) and that, when they do, the latter may have a special indication, as the subscript t.

3. In print, vector or complex quantities should be represented by bold-face letters. In typing, where it is not desired to distinguish Italics for Roman letters, underscoring may be used to indicate bold-face letters, (vectors).

4. For script symbols, other special type may be used.

5. The abbreviations Ω and $\sim$ are recommended for use on diagrams after equations or tables, rather than in running text.

National Academy of Sciences Annual Meeting

The Annual Meeting of the National Academy of Sciences will be held in Washington, April 23, 24, and 25, 1928. All members of the National Research Council are invited to attend the *scientific sessions*, April 23 and 24. It is hoped that chairmen of the Divisions and other members of the Council having unpublished scientific results of unusual importance, which they would like to offer for this program, will promptly submit the titles with abstracts, and preferably manuscript, all in triplicate, before April 10. If lantern slides or films are to be exhibited, this should be noted when the title is transmitted. Programs of the scientific sessions will be mailed to all members of the National Research Council. Address David White, Home Secretary, Washington.

Southern Virginia Section Holds Two-Day Joint Meeting

A joint meeting of the Virginia membership of the A. I. E. E., A. S. C. E. and A. S. M. E. and of the Engineers Club of Hampton Roads was held in the National Bank of Commerce Building, Hampton Roads, Va., January 20 and 21.

The addresses and papers presented were as follows:

Industrial Activities of Tidewater, Virginia, C. J. Calrow, Norfolk-Portsmouth Industrial Commission.

The Industries of Virginia, W. S. Rodman, University of Virginia.

The James, Nansemound and Chuckatuck River Bridges, by W. T. Ballard, The J. E. Greiner Co. and by H. P. Pope, Turner Construction Co.

Introductory Remarks on Modern Communication, C. O. Bickelhaupt, So. Bell Telephone & Telegraph Co.

Pictures by Telephone, C. A. Robinson, Chesapeake and Potomac Telephone Co.

Television, Dr. Herbert E. Ives, Bell Telephone Laboratories.

Transatlantic Telephony, H. P. Charlesworth, American Telephone and Telegraph Co.

Election of officers was reported as follows: Chairman, W. S. Rodman; Secretary-Treasurer, J. S. Miller; Executive Committee, G. C. Boyer and E. W. Husted. These officers were elected for one year beginning at this meeting.

Inspection trips were made on the second day of the meeting. An attendance of 108 was recorded at the largest session.

Pittsburgh Section Holds Midwinter Meeting

A midwinter meeting of the Pittsburgh Section of the Institute in conjunction with the Electrical Section of the Engineers Societies of Western Pennsylvania and the A. I. E. E. Branches of West Virginia University, Carnegie Institute of Technology and University of Pittsburgh was held in Pittsburgh on January 10.

The Student Conference as reported on page 161 of the February JOURNAL was held in the afternoon and in the evening 275 members and guests attended a dinner given in the Chamber of Commerce Building to Bancroft Gherardi, President of the Institute. This was followed by a reception and later address by President Gherardi on *Trans-Atlantic Radio.*

A symposium was then presented on the following subject with scheduled speakers as indicated and discussion by several others.

A-C Network Systems

Engineering Aspects, C. T. Sinclair, Byllesby Engineering and Management Corp.

Operating Performance, H. R. Searing, United Electric Light and Power Co.

Columbia University Scholarships in Electrical Engineering

The governing bodies of Columbia University have placed at the disposal of the American Institute of Electrical Engineers each year, a scholarship in Electrical Engineering in the Schools of Mines, Engineering, and Chemistry of Columbia University for each class. The scholarship pays $350 toward the annual tuition fees which vary from $340 to $360, according to the details of the course selected. Reappointment of the student to the scholarship for the completion of his course is conditioned upon the maintenance of a good standing in his work.

To be eligible for the scholarship, the candidate recommended will have to meet the regular admission requirements, in regard to which full information will be sent without charge upon application to the Secretary of the University or to the National Secretary of the Institute.

In a letter addressed to the National Secretary of the Institute, an applicant for this scholarship should set forth his qualifications (age, place of birth, education, reference to any other activities, such as athletics or working way through college, references and photograph). A committee composed of Messrs. W. I. Slichter, Francis Blossom, and H. C. Carpenter will consider the applications and will notify the authorities of Columbia University of their selection of a candidate. The last day for filing of applications for 1928-1929 will be June 1, 1928.

The course at the Columbia Schools of Mines, Engineering, and Chemistry is three years in length and is on a graduate basis. A candidate for admission must have had something of a general education, including considerable work in mathematics, physics, and chemistry. Three years of preparatory work in a good college or scientific school should be sufficient if special attention has been given to the three preparatory subjects mentioned. A college graduate, with a Bachelor of Science degree in engineering can generally qualify to advantage. The candidate is admitted on the basis of his previous collegiate record, and without undergoing special examinations.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that enrolled students and others qualified will show a keen interest in this scholarship.

Dr. Alexanderson Receives Ericsson Medal

At the 40th anniversary banquet of the American Society of Swedish Engineers in New York, February 11 "for his outstanding contributions to the field of radio engineering," the John Ericsson medal was presented to Dr. E. F. W. Alexanderson, consulating engineer of the General Electric Company, chief engineer of the Radio Corporation of America and a Fellow of the Institute.

The medal has been awarded but once before, when Dr. Svante Arrhenius, former head of the Nobel Institute and the first man to advance the theory of ionization, received it. This presentation was made in Washington at the time of the unveiling of the John Ericsson monument, which was attended by President Coolidge and the Crown Prince and Crown Princess of Sweden.

Dr. Alexanderson, who holds more than 200 patents, recently demonstrated two of his more recent developments, a home television receiver and a device for receiving radio photographs in the home.

Research Graduate Assistantships, University of Illinois

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen Research Graduate Assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the

patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a Research Graduate Assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Additional information may be obtained by addressing The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

United Engineering Society

ANNUAL REPORT

The Board of Trustees (three from each of four societies) conducts the business committed to United Engineering Society by its Founder Societies under its charter, the Founder's Agreement and the Library Agreement.

A draft of a budget of revenue and expenditures for the ensuing calendar year is presented each September to the Secretaries of the Founder Societies for the information and comment of their governing bodies. Each January, reports for the preceding calendar year by the President, the Treasurer, and the Finance Committee, and a financial statement of receipts and expenditures are sent to the office of each Founder Society. Reports are made also by Engineering Societies Library and Engineering Foundation.

Engineering Societies Building is tax exempt. It is administered in the main on a cooperative basis and not for profit. For convenience, and with the aid of experience, assessments for the use of offices have been reduced to the form of rentals and those for use of the meeting halls to a schedule of charges. Offices not used by the Founder Societies and their joint organizations are allotted to Associate Societies. When the meeting halls are not in use by the Founder Societies, other patrons use them to the extent of the demand which it has been practicable to develop. Revenue from Associate Societies and from meeting halls reduces the burden upon the Founder Societies for maintenance, operation, and fixed charges on the building. To each Founder Society, interest at the rate of 4.8 per cent per annum is paid on its investment of $262,500 in the land and building, amounting to $12,600 a year. The building is maintained constantly in good condition and there is a Depreciation and Renewal Fund, a long-range budget provision against major repairs and renewals and the obsolescence of the structure above the foundations. Since it was dedicated in 1907, additions and improvements have been made to the building from time to time, the largest being that of three stories in 1916-17, when the Civil Engineers joined United Engineering Society.

United Engineering Society also administers several trust funds for Engineering Foundation and Engineering Societies Library, and it is seeking a much needed increase of these endowments. In financial operations and management of the property, the Trustee have the services of trust companies as custodians for the funds and advisers in making investments, legal counsel, certified public accountants as auditors and a consulting architect.

Following is an extract of the Annual Report of the Treasurer of the United Engineering Society for the year 1927:

SUMMARY

Operation of Building

Credit Balance January 1, 1927			$ 11,694.24
Building Revenue 1927	$ 134,945.82		
Building Expenditures 1927	115,962.32		18,983.50
			30,677.74
Annual Payment to Dep. & Renewal Fund	$ 12,000.00		
Part cost of Alterations, Basements and 6th Floor	11,346.39		23,346.39
Credit Balance December 31, 1927			$ 7,331.35

Operation of Library

Maintenance Revenue	44,232.92		
Maintenance Expenditures	44,142.92		
Credit Balance Dec. 31, 1927	90.00		
Transferred from Service Bur. Balance	470.14	560.14	
Deficit Dec. 31, 1926		560 14	
Balance Dec. 31, 1927			0.00
Service Bureau Revenue	$ 20,782.76		
Service Bureau Expenditures and Adjustments	19,415.77		
Credit Balance Dec. 31, 1927	1,366.99		
Credit Balance Dec. 31, 1926	1,933.34	3300.33	
Transferred to Maintenance		470.14	
Net Credit Balance Dec. 31, 1927.			$ 2,830.19

Funds and Property

Funds held by U. E. S. Dec. 31, 1927 (Book Value)	
Depreciation and Renewal	208,058.03
General Reserve	7,500.00
Engineering Foundation	504,536.77
Henry R. Towne Engineering	49,953.13
Library Endowment	103,340.97
Reserve for Depreciation of Capital of Library	4,000.00
Edward Dean Adams	100,000.00
John Fritz Medal (U. E. S. Custodian)	3,500.00
Louvain Memorial Subscriptions	12,345.48
Total	993,234.38
Real Estate owned by U. E. S., cost to Dec. 31, 1927	1,973,410.42
Operating cash and petty cash	9,785.95
Accounts Receivable	3,259.74
Value of Library (as appraised for insurance)	349,739.00
Winchell Library Suspense Account	838.00
Total Property for which U. E. S. is Trustee or Custodian.	$3,330,267.49

BALANCE SHEET

Assets

Real Estate		
Land	$ 540,000.00	
Building	1,376,239.26	
Equipment	33,171.16	
Founders Preliminary expenses	24,000.00	$1,973,410.42
Investments and Cash Uninvested		
Depreciation and Renewal Fund		208,058.03
General Reserve Fund		7,500.00
Engineering Foundation Fund		504,536.77
Henry R. Towne Engineering Fund		49,953.13
Library Endowment Fund		103,340.97
Reserve for Depreciation of Library Capital		4,000.00
Edward Dean Adams Fund		100,000.00
Louvain Memorial Fund—Cash in bank		12,345.48
Operating cash and petty cash		9,785.95
Accounts receivable		3,259.74
Winchell Library Suspense Account		838.00
Total		$2,977,028.49

Liabilities

Founders' equity in property	$1,973,410.42
Depreciation and Renewal Fund	208,058.03
General Reserve Fund	7,500.00
Engineering Foundation Fund	504,536.77

Henry R. Towne Engineering Fund	49,953.13
Library Endowment Fund	103,340.97
Reserve for Depreciation of Library Capital	4,000.00
Edward Dean Adams Fund	100,000.00
Louvain Memorial Subscriptions	12,345.48
Louvain Expense Account (Balance on hand)	381.70
Endowment Committee Expense (Balance on hand)	2,494.95
Deposits on account hall rentals	306.50
Deposits Library Service Bureau	39.00
Deferred Credit—Library—Associates Contribution	500.00
Credit Balance in activity accounts	10,161.54
	$2,977,028.49

Respectfully submitted,
JACOB S. LANGTHORN,
Treasurer.

Book Review

THEORIE DER WECHSELSTROMUBERTRAGÜNG (Theory of Alternating-Current Transmission) by Dr. Ing. Hans Grünholz, and published by Julius Springer, Berlin, 1928, 222 pages—130 Illustrations, and 12 tables. The author has made a special study of the system of circle-diagram curves relating to the alternating-current power-transmission circuit, in connection with his studies for the doctorate thesis, and also studies made in 1923 on the design of the first 220-volt transmission line in Germany. Circle diagrams have been worked out and printed in the numerous illustrations of the book, with great care, for a number of particular cases. The book will have special interest for power transmission engineers.

Obituary

W. C. L. Eglin, Fellow of the Institute since 1912, president of the Franklin Institute for five terms, and an electrical engineer of widely recognized ability, died at the Jefferson Hospital, Philadelphia, Pa., February 7, 1928. Mr. Eglin was stricken while on a Carribean cruise. Born in Glasgow, Scotland, July 14, 1870, he was educated in the Andersonian University of Glasgow and the West of Scotland Technological College. As a youth he assisted Rankin Kennedy in his early experimental work on a-c. generators and transformers. He came to America in 1888 and the following year went to work for the Edison Electric Light Company, which, in 1890 combined with others to form the Philadelphia Electric Company, of which Mr. Eglin was vice-president at the time of his death. The amalgamation of these engineering interests impelled the standardization and unification of power-plant equipment and distribution systems throughout the city, and Mr. Eglin was given charge of all this work. Five great steam-electric plants were built under his direction and three years ago, he turned with equal facility to the planning of the hydroelectric plant on the Susquehanna River. (The combined ratings of these steam stations now amounts to 575,000 kw., with 378,000 hp. to be added next fall by the Conowingo system). Nor were Mr. Eglin's ambitions for himself alone; he was anxious to promote all educational and beneficial organizations for the ranks of his employees. In 1890 Mr. Eglin served at the International Engineering Congress, Paris, as a representative of the Engineers' Club of Philadelphia and the Franklin Institute; the University of Pennsylvania, Swarthmore College and other institutions have conferred honorary degrees upon him; he has contributed much to technical literature, both in engineering papers and reports, as well as having delivered his lecture encouraging the promotion of electrical engineering, on "The Power Company and the Distribution of Electrical Energy," before the undergraduates of many colleges, and "The Personnel of the Industry" before the 1919 convention of the Association of Edison Illuminating Companies, offering a plan of education and advancement applicable to all grades of men in the industry. Mr. Eglin was a member of the Edison Pioneers, the Illuminating Engineering Society, the American Electrochemical Society, and many other scientific and fraternal bodies. In his death, the world has lost not only an eminent electrical engineer but a man who was of wide general public benefactor. Mr. Eglin served actively on various Institute Committees and also as its Manager 1903-1906 and Vice-president 1907-1909.

The following minute to his memory was adopted by the Board of Directors at its February 16th meeting:—

The death of Dr. William C. L. Eglin on February 7, 1928 was a great loss to the Institute and to the engineering world. Throughout the long period dating from the beginning of his membership in 1894, he served with marked distinction and loyalty on many of our committees and as a Manager and a Vice-President. No call to him for service ever went unheeded. No work was too arduous for him to undertake. To all of his committee assignments, he brought a vigorous enthusiasm, a resourcefulness, and a breadth of vision which were an inspiration to his coworkers. Few men were his peers in his chosen branch of the electrical industry, of which he was one of the pioneers. The close touch he maintained with the leading scientists of this country and Europe, combined with the viewpoint of a man of affairs, enabled him to contribute effectively to the advancement of electrical engineering.

The Board of Directors, mindful of Dr. Eglin's distinguished career and his adherence to the highest engineering ideals, conveys to his family and associates its deep sympathy, and orders this minute spread upon the records.

Augustus T. Holbrook, for several years sales manager of the Miniature Breaker Company, Inc., Long Island City, but for the past several months forced into retirement by ill health, died at the Flower Hospital January 12, 1928. Mr. Holbrook was born at Greenport, L. I., February 18, 1872, and after going through business college soon determined upon the electrical profession for a career. January 1, 1901, he joined the Westinghouse Electric & Manufacturing Company, but the following year was transferred to the Nernst Lamp Company, of which he ultimately became manager for the New England States, with headquarters at Boston. His work in the electrical field was varied, but showed professional progress in all undertakings. To him is due a share of the credit for the development of the excess current relay, upon which he worked with Mr. A. W. Burke of Philadelphia. Mr. Holbrook also contributed liberally to the literature of the National Electric Light Association. His late interests have been in the development of electrical appliances, and the promotion of electrical sales organizations. He became a member in 1921.

James Wilfred Harris, late of Alfred Wiseman, Ltd., Mechanical and Electrical Engineers, Birmingham, England, died January 14. He was a native of Bilston Staffs, England, and was educated at King Edward's School, Birmingham, followed by an electrical education at Meson's and Tinsbury Colleges. For three years thereafter he studied in the shops and drafting room of an electrical construction company, and for another two years was doing the actual construction work for the same company on central stations and street railways, assisting in the equipment of the Liverpool overhead and Halifax Street Railways. Mr. Harris then went abroad, taking up work in some of the most important power plants in India, China, Japan and the Pacific Coast of America. For 12 months he was shift engineer for the West Kootenay Power & Light Co., Bonnington Falls, B. C., and then joined the British Westinghouse Electric & Mfg. Co., Ltd., at Pittsburgh, passing through the shops and tests and was sent over to Trefford Park to equip the works there with a power plant. Mr. Harris has been a member of the Institute since 1904.

Johannes Johansen, chief operator of power and substations for the Fruitvale Power Station, Southern Pacific, died December 26, 1927. In his death his company feels that they have lost a man whose value it is difficult to overestimate. Mr. Johansen was born and educated in Denmark, but like many of his countrymen, left for political reasons. He came to the States and with a well-trained mind and earnestness of purpose which soon won for him the confidence and admiration of all those with whom he came in contact, he made steady progress. Mediocrity had no place in his calculations and by dint of his

own hard labors, his ambitions carried him to success in all his undertakings. From 1891 to 1903, Mr. Johansen was with the Edison Electric Illuminating Company of Brooklyn, for the last six years of that period acting as District Foreman of Operation. He then became operator for the Interborough Company, New York, until 1905, and for the Port Morris Power Plant, New York Central Railroad Company until 1911, when he was appointed to the position which he held at the time of his death and in which he has rendered faithful and efficient service for nearly twenty years. Mr. Johansen's friendliness and geniality knew no confines; all who knew him mourn his loss as a personal friend.

Charles Vernier, chief engineer of The Macintosh Cable Company, Ltd., Walton, Liverpool, died January 9, 1928, of pneumonia, following a nervous breakdown. Born at London, April 15, 1877, he was educated there at the Regent Street Polytechnic and the City and Guilds of the London Technical College, Finsbury. He served an apprenticeship with Messrs. Reyrolle & Company, manufacturing electrical engineers of London and gained further experience with London firms on general engineering and instrument work. He was electrician in charge of testing work with Brockie Pell Arc-Lamp Company, London; assistant engineer on Mains work with the Cork Electric Tramways and Lighting Company under Charles H. Nerz and Col. W. McLellan; chief mains engineer with the Newcastle-on-Tyne Electric Supply and Associated Companies; and for 20 years had charge of the whole of the Newcastle Electric Supply Company; also, from the date of its absorption by them, of the Associated Companies' mains constructions, repairs and maintenance work. His notable works were (1) the laying down of the first large 20,000-volt underground cable system in the world, in County Durham, England. This comprised, initially, 40 mi. of 20,000-volt three-core cable in 1906, with continuous extensions in that and adjoining counties in subsequent years; and (2) the laying of the first 66,000-volt cables and 66,000-volt overhead transmission lines in Great Britain, the first of which were undertaken in 1923. Mr. Vernier was a very active member of the Institution of Electrical Engineers, having held many of its important executive offices and served on its Council from 1920 to 1923 with a career of high promise. He was elected a Fellow of the A. I. E. E., June 1927.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail, through the accuracy of our mailing records and the elimination of unnecessary expense for postage and clerical work:

Sydney O. Clarke, 824 St. Nicholas Ave., New York, N. Y.
J. H. Michelsen, Pacific Elec. Mfg. Co., San Francisco, Calif.
N. O. C. Miller, 1406 E. Poplar St., Stockton, Calif.
Henry C. B. Morris, 87 N. Munn Ave., East Orange, N. J.
W. A. Nelson, 3800 Ravenswood Ave., Chicago, Ill.
F. R. Reynolds, 1623 Wyoming Ave., Kingston, Pa.
C. B. Rice, 81 Park Ave., New York, N. Y.
Meade G. Spears, 9 Hancock St., Brooklyn, N. Y.
P. Taylor, 122 W. 103rd St., c/o Guilfoyle, New York, N. Y.
Wm. W. Van Sant, 531 Elm St., Reading, Pa.
Kurt Geo. Wendt, c/o Public Service Co., Kankakee, Ill.

A. I. E. E. Section Activities

Future Section Meetings

Cleveland

Joint meeting with Case School of Applied Science Branch. March 22.

Interconnection of Power Systems, by Philip Sporn, Elec. Engr., American Gas and Electric Co. April 19.

Columbus

Joint dinner meeting with Engineers' Club of Columbus. March 23.

Joint meeting and smoker with O. S. U. Branch. April 27.

Erie

Tendencies in Modern Transportation, by N. W. Storer, Westinghouse Electric & Mfg. Co. March 20.

The Use of Mechanical Ideas in Electricity, by W. S. Franklin, Massachusetts Institute of Technology. April 17.

Lynn

The Grand Canyon. Southeastern Utah, the Zion and Bryce Canyons, by Randall Jones. Ladies' Night. First M. E. Church, City Hall Square. March 7.

Personal Reminiscences of Heaviside and Steinmetz, by Dr. E. J. Berg, Consulting Engr., General Electric Co Annual Banquet. March 31.

New York

Lightning and Lightning Protection, by F. W. Peek, Jr., General Electric Co. March 22.

Niagara Frontier

Talking Movies, by L. T. Robinson, General Electric Co. March 30.

System Insulation and Protection, by C. L. Fortescue, Westinghouse Electric & Mfg. Co. April 20.

Pittsburgh

Vacuum Tube Applications, by T. A. E. Belt, General Electric Co. March 13.

Arc Phenomena, by Dr. Joseph Slepian, Westinghouse Electric & Mfg. Co. April 10.

Pittsfield

Conditions in China, by Dr. Tehyi Hsieh. Masonic Temple. March 6.

Power Transmission, by Philip Sporn, The American Gas and Electric Co. Stanley Club Rooms. March 24.

Annual Dinner. Speaker: Charles Milton Newcomb. April 3.

St. Louis

Television, by Dr. H. E. Ives, Bell Telephone Laboratories. March 21.

Arc Welding, by K. L. Hansen, Consulting Engineer. April 18.

Sharon

Meeting in Y. M. C. A. Auditorium, Youngstown, O. Addresses and lantern slides. Inspection of 132-kv. substation. Transportation in P. & O. busses. March 6.

Developments in Power Generation and Transmission, by F. C. Hanker, Westinghouse Electric & Mfg. Co. April 3.

Vancouver

Railway Motors, by H. M. Lloyd. April 3.

SECTION MEETINGS

Atlanta

Advancement of the Engineer, by W. E. Mitchell, Georgia Power Co., and

Television, by Dr. H. E. Ives, Bell Telephone Laboratories. Illustrated. A dinner preceded the meeting. Joint with A. P. M. E. January 23. Attendance 220.

Chicago

Regional Power Survey, by M. M. Fowler, General Electric Co., and P. B. Juhnke, Commonwealth Edison Co. October 31. Attendance 260.

The Electric Arc, by Dr. Joseph Slepian, Westinghouse Electric & Mfg. Co. January 16. Attendance 180.

Cincinnati

Recent Problems in High-Voltage Interconnections in the East, by Prof. J. L. Beaver, Vice-President, District No. 2. Prof. Beaver also spoke on Institute affairs. A dinner preceded the meeting. January 12. Attendance 41.

Cleveland

Today's Science—Tomorrow's Engineering, by L. A. Hawkins, General Electric Co. Motion pictures, entitled "Liquid Air" and "Beyond the Microscope," were shown. January 19. Attendance 130.

Columbus

Power by Radio, by Dr. Phillips Thomas, Westinghouse Electric & Mfg. Co. A dinner preceded the meeting. Joint meeting with Ohio State University Branch. January 6. Attendance 200.

Electrical Heating and Its Application, by H. J. Babcock, General Electric Co. Motion picture on "Cuba, the Island of Sugar," preceded the talk. January 27. Attendance 38.

Denver

Electricity in Oil-Field Operations, by E. W. Peake, Midwest Refining Co. Illustrated. A dinner preceded the meeting. January 31. Attendance 60.

Detroit-Ann Arbor

Industrial Motor Control, by H. D. James, Westinghouse Electric & Mfg. Co. A dinner preceded the meeting. January 17. Attendance 100.

Erie

Recent Developments in the Art of Communication, by S. P. Grace, Bell Telephone Laboratories. January 17. Attendance 350.

Fort Wayne

Hand-Made Towns, by Dr. F. E. Jaynes, American City Bureau, Chicago. January 19. Attendance 38.

Indianapolis-Lafayette

Manufacture of High-Voltage Porcelain Insulators and Accessories, by A. M. Jackson, Locke Insulator Corp. December 16. Attendance 64.

Dissipation of Heat in Underground Conduits for Electrical Conductors, by Prof. C. C. Knipmeyer, Rose Polytechnic Institute;

Recent Developments in Long Toll-Telephone Cables, by H. S. Sheppard, American Tel. & Tel. Co., and

Some Little Known Facts Regarding Radio Communication, by D. J. Angus, Esterline-Angus Co. Joint meeting with Indiana Engg. Society. A buffet luncheon was served after the meeting. January 27. Attendance 111.

Ithaca

The Assemblage of Equipment to Make Up a Complete Power-Station Design, by R. J. S. Pigott, Public Service Production Co. Joint meeting with A. S. M. E. December 9. Attendance 195.

Traffic in the Field of Radio Communication, by F. H. Kroger, Radio Corporation of America. January 26. Attendance 60.

Kansas City

High-Grade Telephone Toll Circuits, by A. B. Covey, Southwestern Bell Telephone Co. Accompanied by demonstration. January 23. Attendance 60.

Lehigh Valley

Methods of Starting Induction and Synchronous Motors, by L. R. Woodhull, Bethlehem Mines Corp., and C. W. Falls, General Electric Co. January 21. Attendance 66.

Los Angeles

The Coordination of Researches, by E. B. Craft, Bell Telephone Laboratories. The meeting was preceded by a dinner. January 31. Attendance 193.

Louisville

Automatic Signaling and Automatic Train Control, by P. P. Ash and F. T. Fereday. January 10. Attendance 33.

Lynn

The Antiquity of Man, by Dr. R. S. Lull, Yale University. Illustrated. January 20. Attendance 375.

Modern Metering, by H. M. Witherow, General Electric Co., and

Remote Metering, by H. B. Rex, General Electric Co. February 1. Attendance 69.

Inspection trip to the South Boston Dry Dock to inspect the Airplane Carrier *Lexington*. February 4. Attendance 296.

Mexico

Dinner Meeting. January 10. Attendance 32.

The Teletype, by K. K. Carroll. February 7. Attendance 52.

Milwaukee

Policies and Plans of the Milwaukee Harbor Commission, by F. A. Kaiser, Harbor Engineer, and K. A. Albrecht, Traffic Director. January 18. Attendance 70.

Niagara Frontier

Simple Electric Transients and Traveling Waves, by V. Karapetoff, Cornell University. A piano recital was also given by the speaker. A dinner preceded the meeting. January 13. Attendance 155.

Pittsburgh

Midwinter Dinner Meeting, joint with Electrical Section, Engineers Society of Western Pennsylvania. (See details elsewhere in this issue.) January 10. Attendance 275.

Pittsfield

Advertising, by Bruce Barton. A dinner preceded the meeting. January 10. Attendance 800.

Ten Years' Advancement in Power-Station Design, by F. S. Collings, Sargent and Lundy, Inc. A dinner preceded the meeting. January 24. Attendance 135.

Floods and Flood Control, by Dr. Frank Bohn. February 7. Attendance 400.

Rochester

Recent Developments in Powdered Coal, by Henry Kreisinger, Combustion Engineering Corp. Joint meeting with A. S. M. E., January 20. Attendance 78.

St. Louis

Smoke Prevention, by W. G. Christy, and

Important Raw Materials Used in the Telephone Industry, by G. S. Rutherford, Western Electric Co. January 18. Attendance 48.

San Francisco

Eight Years of Research in Lightning Phenomena and Surges, by Dr. Harold Norinder. Joint meeting with P. C. E. A. January 13. Attendance 130.

Coordination of Research, by E. B. Craft, Bell Telephone Laboratories. Illustrated. A dinner preceded the meeting. January 24. Attendance 500.

Saskatchewan

The Constitution of Matter, by R. N. Blackburn, and

Developments in the Flin Flon Mining Area, by W. Hastings. January 20. Attendance 54.

Schenectady

The Evolution of the Science and Art of Illumination, by W. D'A. Ryan, General Electric Co. Illustrated. January 20. Attendance 175.

Seattle

Coordination of Researches, by E. B. Craft, Bell Telephone Laboratories. January 13. Attendance 124.

Sharon

The Raising of the Submarine S-51, by Lieutenant-Commander Edward Ellsberg, Tidewater Oil Co. January 7. Attendance 386.

Southern Virginia

Joint meeting with A. S. C. E. and A. S. M. E. (See details elsewhere in this issue.) January 20-21.

Springfield

High-Capacity Mercury Arc Rectifiers, by F. A. Faron, General Electric Co. Illustrated with slides. January 23. Attendance 36.

Syracuse

The Utility as a Citizen, by W. K. Bradbury, Buffalo, Niagara and Eastern Power Corp. January 16. Attendance 150.

Toledo

Ladies' Night. January 20. Attendance 50.

Toronto

Insulation, by W. P. Dobson, Hydro-Electric Power Comm. of Ontario. Illustrated with slides. November 25. Attendance 78.

Applications of High-Frequency to Control and Communication, by C. A. Boddie, Westinghouse Electric & Mfg. Co., December 9. Attendance 68.

Urbana

Stability of Transmission Systems, by A. D. Dovjikov, Westinghouse Electric & Mfg. Co. December 15. Attendance 150.

Utah

Use of Underground Cables, by P. P. Ashworth, Utah Power & Light Co., and

Installation of Underground Cables, by C. F. Cassidy, General Electric Co. January 12. Attendance 40.

Vancouver

Inspection trip to the Fire Alarm System. January 10. Attendance 35.

Electrolytic Rectifiers, by Mr. Parsons;

Current-Transformer Errors and Methods of Testing, by Messrs. Duncan and Harvey;

The Rotary Converter Room at Trail, B. C., by Mr. Newmarch;

Heat Treatment of Steel, by Mr. Tupper, and

New Method for Overcoming Dead-Center on Engines, by Mr. Sinclair. These papers were presented by students at the University of British Columbia. February 7. Attendance 41.

Washington

High Steam Pressures, by N. E. Funk, Philadelphia Electric Co.; A. R. Smith, General Electric Co., and Mr. Waldbridge, Westinghouse Electric & Mfg. Co.;

Use of Pulverized Fuels, by Henry Kreisinger, Combustion Engineering Corp.; and

Use of Powdered Coal, by Commander Evans, U. S. N.; C. J. Jefferson, U. S. Fleet Corp., and Capt. R. D. Gatewood, U. S. N. February 10. Attendance 170.

Worcester

The Power-Factor Situation, by R. W. Adams, General Electric Co. Meeting was preceded by a dinner. January 18. Attendance 50.

A. I. E. E. Student Activities

STUDENT MEETING HELD BY VANCOUVER SECTION

At the meeting of the Vancouver Section held February 7, 1928, the following program was presented by members of the 1928 class of the University of British Columbia:

Electrolytic Rectifiers, with account of original research, by Mr. Parsons.

Current Transformer Errors and Methods of Testing, by Mr. Duncan and Mr. Harvey.

The Rotary Converter Room at Trail, B. C., by Mr. Newmarch.

Heat Treatment of Steel, by Mr. Tupper.

New Method for Overcoming Dead-Center on Engines, by Mr. Sinclair.

The papers were of excellent grade, and were deeply appreciated by the audience.

LECTURES ON ACCIDENT PREVENTION

The National Safety Council has recently published in pamphlet form the first two lectures on accident prevention prepared under the supervision of it's Committee on Promoting Accident Prevention in Engineering Colleges. The titles are "Accident Prevention, A Factor In Engineering" and "Preventing Accidents on Woodworking Machines."

These lectures are intended primarily for presentation to engineering students either in connection with regular courses or at meetings of the student branches or chapters of the national engineering societies. Single copies have been sent by the Council, to the deans of all engineering colleges.

CONFERENCE ON STUDENT ACTIVITIES TO BE HELD IN SOUTHERN DISTRICT

Since early last fall the Committee on Student Activities of the Southern District (No. 4) has been working upon the details of a combined Student Convention and Conference on Student Activities, and has decided to hold the meeting at the Georgia School of Technology, Atlanta, Georgia, March 30-31.

Questionnaires and voluntary suggestions have brought out the ideas of the Counselors and members of the Branches, and have shown that great enthusiasm and unity of purpose exist. All concerned are looking forward with anticipation to a meeting which will bring individuals, Branches, and colleges into a better understanding and appreciation of their common purpose and the ideals and activities of the Institute.

The suggested program for the meeting includes an address of welcome by Vice-President C. O. Bickelhaupt, and three technical papers by Counselors Friday morning; six student technical papers Friday afternoon; a joint meeting with the Atlanta Section Friday evening; a Conference on Student Activities Saturday morning; and inspection trips Saturday afternoon.

Plans for the meeting are being made under the direction of Professor Earle S. Hannaford, Counselor of the Georgia School of Technology Branch, and Chairman of the District Committee on Student Activities.

BRANCH MEETINGS

Municipal University of Akron

Twin Coach, by G. E. Burkholder, student, and

Wire Drawing, by J. C. Schacht, student. Motion picture, entitled "Beyond the Microscope," was shown. January 13. Attendance 13.

Alabama Polytechnic Institute

Opportunities Offered to Young Graduates in the Electrical Engineering Field, by Mr. Klottman, Westinghouse Electric & Mfg. Co. Discussion of proposed inspection trips to three big projects of the Alabama Power Company. December 1. Attendance 50.

The Locke Insulator Company and Its Products, by L. W. Carnagy, District Manager, Locke Insulator Corp., Atlanta, Ga. December 8. Attendance 65.

The meeting was conducted in the form of an old-time spelling match. Scientific questions were prepared by several men appointed by the Secretary. December 15. Attendance 46.

Business Meeting. The following officers were elected: Chairman, C. T. Ingersoll; Vice-Chairman, C. D. Bradley; Secretary-Treasurer, W. P. Smith; Auburn Engineer Reporter, L. B. Hallman; and Plainsman Reporter, J. J. O'Rourke. January 5. Attendance 54.

Metering, by G. L. Kenny, Gulf Electric Co., Mobile;

The Recent Developments in Radio, by W. R. Coleman, Jr., and

Radio Communication, by A. M. Dunstan. January 12. Attendance 50.

Cottrell Precipitation Process, by J. R. Alexander, student, and

Foundry Work, by W. T. Edwards, student. February 2. Attendance 58.

University of Arkansas

Correcting for Excessive I R Drop in Transmission Lines, by E. R. McClusky, student. The Branch decided to hold meetings on first and third Tuesdays of each month. January 18. Attendance 29.

Activities of the Chamber of Commerce, by Scott Hamilton, Secretary, Fayetteville Chamber of Commerce. January 31. Attendance 15.

Bucknell University

Discussion of plans for the joint meeting of Bucknell University Branch with Pennsylvania State College Branch to be held at State College, Pa., on March 7. A. R. Ulmer elected as Branch Safety Representative. January 31. Attendance 15.

California Institute of Technology

Power Plant Design, by J. N. Hatch. January 13. Attendance 21.

Motion picture, entitled "The Induction Voltage Regulator," was shown. January 27. Attendance 24.

The Electromagnetic Recording of Phonograph Records, by Dr. D. H. Loughridge, R. C. Burt Laboratories. February 3. Attendance 11.

University of California

Transatlantic Telephony, by A. E. McMahon, Pacific Tel. & Tel. Co. Motion picture, entitled "Talking Across the Ocean," accompanied the lecture. Various items of business transacted. January 25. Attendance 59.

Carnegie Institute of Technology

Joint meeting with University of Pittsburgh and West Virginia University Branches. For report of meeting, see Student Activities dept. of February JOURNAL. January 10. Attendance 150.

Radio Interference from a Central Station Viewpoint (with demonstrations), by J. M. Frolick, Duquesne Light Co. January 11. Attendance 50.

Case School of Applied Science

The Generating and Distributing System of the Cleveland Electric Illuminating Company, by H. L. Wallau, Chief Electrical Engineer. The meeting was preceded by a dinner. February 9. Attendance 34.

Clarkson College of Technology

History of the American Navy, by F. H. Reynolds, Instructor in Chemistry, and

Finances of the Engineer, by G. L. Rogers, Chairman. Joint meeting with Clarkson Chemical Society. Refreshments followed the meeting. January 24. Attendance 40.

University of Colorado

Some Points of Interest about General Electric Company, by W. B. Clark, Sales Engineer, General Electric Co. Illustrated;

Opportunities with the General Electric Company, by M. M. Boring, Industrial Service Dept., Schenectady;

The New Cooper-Hewitt Industrial Mercury Vapor Lamp and the Neon Tube, by A. S. Anderson, Denver Office, General Electric Co. Demonstrated;

The Manufacture and Uses of Fused Quartz, by B. J. Rowan, and

Demonstration of the Photoelectric Cell, by R. H. Owen, KOA Broadcasting Station. January 25. Attendance 200.

Financing Public Utility Securities, by J. E. Loiseau, Head of the Securities Dept. of the Public Service Co., Denver. John R. Outt was appointed Safety Representative. Refreshments were served at the close of the program. February 1. Attendance 40.

University of Denver

Sources of Stellar Energy, by Vernon Cato. A motion picture, entitled "The Conquest of the Forest," was shown. January 13. Attendance 31.

Drexel Institute

Pyrometers, by A. T. Williams, Brown Instrument Co. February 3. Attendance 32.

University of Idaho

The Conduction of Heat from Underground Electric Cables, by N. P. Bailey, Instructor in Civil and Electrical Engineering. January 11. Attendance 28.

University of Kansas

Motion pictures, entitled "The Light of the Race" and "The Horseless Carriage," were shown. The following officers were elected: Chairman, R. M. Alspaugh; Vice-Chairman, E. H. Sills; Secretary, W. A. Wolfe; Treasurer, E. B. Hite. Joint meeting with student branch of A. S. M. E. prior to election of officers. January 12. Attendance 80.

University of Kentucky

Business Meeting. Adoption of By-laws. January 11. Attendance 31.

Lafayette College

Prof. Morland King showed moving pictures of Atomic Hydrogen Welding and of the Largest Single-Unit Electric Locomotive. Discussion of plans for the Student Branch Convention of the Philadelphia and Lehigh Valley Sections. January 21. Attendance 22.

Louisiana State University

What a Young Engineer Can Expect When He Leaves College, by Mr. Davis, Baton Rouge Electric Co. Several items of business discussed. January 12. Attendance 25.

Lewis Institute

Fuel Burning Devices and Methods, by T. A. Marsh, Combustion Engineering Co. Joint meeting with the W. S. E. Branch. January 17. Attendance 90.

Chicago Regional Power Supply, by P. B. Juhnke, Chief Load Dispatcher, Commonwealth Edison Co. January 31. Attendance 110.

Motion pictures, entitled respectively "Pictures by Wire," "Electrical Transmission of Speech by Wire," and "Television," were shown. February 2. Attendance 90.

University of Maine

A Comparison of Amplifiers and Loudspeakers, by Prof. W. J. Creamer. Report on the convention of Institute of Radio Engineers in New York City. January 18. Attendance 32.

Motion picture, entitled "The Romance of Telephony," was shown. January 19. Attendance 40.

Ship Propulsion, by N. J. Linnell, student. Motion picture, entitled "Queen of the Waves," was shown. February 8. Attendance 42.

Motion pictures on Television were shown. February 9. Attendance 41.

Motion pictures on Transportation were shown. February 13. Attendance 19.

Marquette University

Engineering in the Business World, by George Phelps, First Wisconsin Co. January 12. Attendance 27.

The Design and Construction of Urban Distribution Systems, by P. P. Stathas (alumnus) Field Engineer, Milwaukee Electric Railway and Light Co. Annual banquet to be held March 15. February 9. Attendance 40.

Michigan State College

Experiences with the Illinois Traction Company, by Prof. L. S. Foltz, Counselor;

Experiences with the Commonwealth Power Corporation of Michigan, by H. J. Kurtz;

Experiences with The Detroit and New York Edison Companies, by Prof. A. Naeter. Prof. M. M. Cory gave a talk on the General Electric Student Course and Mr. Kinney spoke on some types of State work. January 17. Attendance 39.

University of Michigan

Industrial Motor Control, by H. D. James, Westinghouse Electric & Mfg. Co. January 19. Attendance 85.

University of Minnesota

Television, by Dr. J. O. Perrine, Bell Telephone Laboratories, Inc. Illustrated. Members of the Minnesota Section were guests of the Student Branch. January 12. Attendance 400.

Mississippi A. & M. College

Design and Construction of Armatures and Transformers, by A. L. Moore, New Orleans Office, General Electric Co. A film, descriptive of the Fort Wayne, Indiana, plant of the Company, was shown. January 10. Attendance 84.

Missouri School of Mines

Discussion of programs for future meetings. Decided that President should appoint a program committee. November 16. Attendance 14.

Motion picture on Power Transformers was shown. December 6. Attendance 36.

Mercury Arc Rectifiers, by Paul Berry. December 7. Attendance 21.

Motion picture, entitled "Making Mazda Lamps," was shown. December 13. Attendance 33.

University of Missouri

Talking Motion Pictures, by E. J. Lawton, student;

Development of the Telephone, by C. E. Schooley, student, and

The Holland Tunnel, by G. L. Crow, student. February 7. Attendance 38.

Montana State College

Improvement in Loading Coils by the Use of Permalloy. (Extract from an article in the *Electrical World* for January 7, 1928.) Read by Carl Oberbauer, student. January 12. Attendance 126.

Lightning Prevention. (An abstract from an article by Colonel E. H. Wilcox in the December number of the *Scientific American.*) Read by F. E. Heikkila, student. January 26. Attendance 124.

Newark College of Engineering

A-C. Radio Tubes, by H. M. Freeman, Westinghouse Lamp Co. of Bloomfield, N. J. Discussion of plans for N. Y. Section Student Convention. January 16. Attendance 24.

The Gyroscope, by R. L. Witham, Electrical Engineer, Sperry Gyroscope Co. Accompanied by three-reel motion picture on the "Action of the Gyroscope." January 30. Attendance 33.

College of the City of New York

Fifty Years of Progress in Building of Bridges, by D. B. Steinman, graduate of and former instructor at C. C. N. Y. Joint meeting with A. S. C. E. and A. S. M. E. January 12. Attendance 48.

New York University

Development and Research Work on Long-Distance Toll Cables, by H. S. Shepard, Executive Assistant to Dr. F. B. Jewett, A. T. & T. Co. Motion picture, entitled "A Prophecy Fulfilled," was shown. Plans have been made to hold bi-weekly meetings. Discussion of plans for New York Section Student Convention. February 9. Attendance 36.

University of New Hampshire

Some Bearing Investigations, by T. W. Colby and E. A. Goodwin;

How to Develop a Pleasing Personality, by M. W. Cummings anp I. Gove, and

What a Flood Means to a Plant Engineer, by T. Elliott and E. E. Lafond. January 16. Attendance 39.

Automatic Railway Substations, by H. E. Fuller and L. L. Landon;

Ventilating the Pittsburgh Tunnel, by M. S. Hodgdon and H. W. Lawry, and

The Eighth Wonder, by R. M. Knight and J. M. Lee. January 23. Attendance 39.

Motion picture, entitled "Conowingo," was shown. January 30. Attendance 39.

University of North Carolina

Telephone Research, by John Mills, Director of Publication, Bell Telephone Laboratories, Inc. Discussion of an Engineers Dance to be sponsored by the local branches of the A. S. C. E. and A. I. E. E. January 13. Attendance 45.

The Holland Tunnel, by Prof. J. E. Lear. Discussion of the prospective Engineers Dance. January 26. Attendance 34.

Transformer Locations in Signal Service, by J. M. Maxwell, student. Report on arrangements for the Engineers Dance. The following officers were elected: President, J. D. McConnell; Vice-President, C. R. Jones; Secretary, J. S. Kirk, and Treasurer, W. C. Burnett. February 9. Attendance 27.

University of North Dakota

Benefits Derived from Student Training Courses, by Syvert Gunnes, Shafer Oil Co. Film on the Frequency Converter was shown. January 12. Attendance 16.

University of Notre Dame

The Functions of Transformers in Radio Circuits, by Mr. Moyer, a junior. Illustrated talk on "Railway Signaling" by Mr. Loeffler, a senior. Refreshments served. January 9. Attendance 71.

Life of Alexander Graham Bell, by Laurence Wingerter, student, and

Characteristics of Harmonics Due to Condensers in Oscillatory Circuits, by Dr. Favier, Indiana and Michigan Electric Co. January 23. Attendance 67.

Ohio Northern University

Short business session followed by a talk on "Carrier Current Telephone Transmission" by E. C. Smith. L. R. Althaus spoke on "Chemical Condensers of Large Capacity." January 5. Attendance 29.

Mercury Arc Rectifiers, by C. Wolley, and

The Uses of Electricity in the Holland Tunnel, by W. G. Hensel. Discussion of "Engineers' Week." January 19. Attendance 14.

Insulators and Their Characteristics, by Marion Runyon. Discussion of Spring inspection trip. February 3. Attendance 21.

University of Oklahoma

Discussion of stunts for Open House. February 2. Attendance 23.

Oregon State College

Business Meeting. Discussion of plans for the annual Educational Exposition, in which the Branch sponsors the electrical engineering exhibits. January 11. Attendance 42.

The Resistance of a Rectangular Conductor, by S. O. Rice, and

The Portland Installation of Mackay Radio and Telegraph Company, by B. G. Griffith. Artro Swingle was appointed Safety Representative. February 1. Attendance 43.

Pennsylvania State College

The Theory of Indicating Instruments, by A. F. Corby, Jr., Weston Electrical Instrument Corp. January 25. Attendance 29.

University of Pittsburgh

A-C. Radio Tubes, by R. H. Capek, and

Our Next World War, by I. L. Chabot. January 6. Attendance 45.

Joint meeting with West Virginia University and Carnegie Institute of Technology Branches. For report of meeting, see Student Activities department of February JOURNAL. January 10. Attendance 80.

Electrical Reproduction of Phonograph Records, by J. G. Hoop. January 20. Attendance 38.

The Theory and Principles of Electrical Measuring Instruments, by A. F. Corby, Jr., Weston Electrical Instrument Corp. January 27. Attendance 38.

Princeton University

Power and Lighting of the Holland Vehicular Tunnel, by Prof. M. MacLaren, Counselor. January 23. Attendance 10.

Rensselaer Polytechnic Institute

Simple Theory of Relativity, by R. A. Patterson, Professor of Physics. January 10. Attendance 180.

Rhode Island State College

Television, by C. T. Miller, senior. December 2. Attendance 31.

Building Construction, by J. L. Morrison, Bigelow, Kent and Willard Co., architects, Boston. December 9. Attendance 44.

Electrification of the Virginian Railway, by Charles Wales, Instructor in E. E. December 16. Attendance 26.

Two motion pictures, entitled respectively "Beyond the Microscope" and "The Wizardry of Wireless," were shown. January 6. Attendance 37.

Recent Developments in Transmission Lines, by L. A. Duckworth, senior, and

Transformers, by Prof. W. A. Anderson, Counselor. January 13. Attendance 20.

Rose Polytechnic Institute

Incandescent Lamps, by Mr. Davidson, student. Illustrated with slides. January 18. Attendance 42.

Rutgers University

Power Supply for New Jersey Industries, by S. Q. Hayes, General Engineer, Westinghouse Electric & Mfg. Co. January 9. Attendance 89.

University of Santa Clara

Business Meeting. R. P. O'Brien, Chairman and A. D. Hinkley, Counselor, gave talks on the advantages of Student enrollment in the A. I. E. E. A motion was passed that the members of the Branch assess themselves twenty-five cents each as a subscription for the clock and carillon to be installed in the new Louvain Library as a war memorial to American Engineers. January 10. Attendance 28.

University of South Dakota

Electrified Railroads, by Mr. Hayward. December 14. Attendance 7.

Business Meeting. Nomination of officers. January 18. Attendance 9.

Business Meeting. The following officers were elected: Chairman, Charles Cantonwine; Vice-Chairman, Howard Crosby; Secretary, Paul Schell. William Dickenson elected Safety Representative. February 8. Attendance 12.

University of Southern California

Organization and Work of the Southern California Telephone Company, by Mr. Rutherford, Southern California Telephone Co. January 11. Attendance 45.

Luncheon Meeting. Lester Bateman and L. F. Slezak were re-elected Chairman and Secretary, respectively. Zoeth Cummings elected Vice-Chairman and J. W. Gilroy, Treasurer. January 25. Attendance 46.

Stanford University

The 100-Kw. Tube, by R. W. Clark;

G. N. R. R. Electrification, by E. H. Fisher, and

Electric Steel Mill Drives, by P. E. Warrington. Chairman D. E. Chambers spoke on proposed Engineering Council of Stanford University. Motion that the Branch affiliate with the Council carried. Program Committee appointed. January 12. Attendance 22.

Inspection trip to the Central Office and two Automatic Substations of the Pacific Gas and Electric Company in Oakland. January 21. Attendance 21.

Transformers, Their Design and Construction, by A. W. Copley, Manager, Engineering Division, Westinghouse Electric & Mfg. Co., San Francisco. Illustrated with slides. January 26. Attendance 25.

Latest Electrical Receivers, by George T. Royden, Mackay Radio and Telegraph Co. Joint meeting with Stanford University Radio Club. February 1. Attendance 30.

Swarthmore College

Problems Confronting the Telephone Engineer in Buying Property for Central Offices, by Mr. Griest, Director of Results, Bell Telephone Company of Pennsylvania. Slides.

Some of the Problems the Student Engineers Have to Decide When Out of College, by Mr. Wattles, Director of College Relations, Bell Telephone Company. Following the talks motion pictures on Telephone Circuits and Transatlantic Telephony were shown. January 19. Attendance 35.

Syracuse University

Power Development in Japan, by Earl Gilchrist, and

Synchronization in A-C. Practise, by John Walsh. December 2. Attendance 10.

Engineering Achievements of Westinghouse Electric & Mfg. Company in 1927, by Robert Schwarting. December 9. Artendance 10.

Films, entitled "The Electrical Giant" and "Power Transformers," were shown. December 16. Attendance 33.

Film, entitled "The Benefactor," was shown. January 6. Attendance 20.

Film, entitled "The Story of Power," was shown. January 13. Attendance 20.

Business Meeting. Robert Schwarting appointed Safety Representative. Discussion of programs for next semester. February 9.

University of Tennessee

Moving pictures of The Tennessee Electric Power Co. January 11. Attendance 29.

University of Utah

Experiences in the Employ of the Forest Air Service of California, by W. H. Campbell, student. The "Suggested By-laws for Student Branches" were adopted with slight modifications. January 10. Attendance 25.

Motion picture, entitled "Water Power," was shown. January 13. Attendance 77.

Virginia Military Institute

Electrical Equipment of the Holland Tunnel, by W. H. Old;

Mortality of the Bell Telephone Company, by R. B. Batte, and

Experiences with Westinghouse Electric & Mfg. Co., by J. O. Couch. February 8. Attendance 31.

Virginia Polytechnic Institute

The Storage Battery, by Prof. J. B. Lucas. January 23. Attendance 31.

The Electron, by Dr. F. L. Robeson. February 1. Attendance 30.

State College of Washington

The Ring Feeder, by J. T. Pringle, student. January 5. Attendance 20.

Business Meeting. The following officers for next semester elected: President, H. B. Tinling; Vice-President, G. M. Brown; Secretary, J. B. Danielson; Treasurer, Henry Kahl; Executive Council, J. R. Hansen and T. S. Hall. The above men are to take office at once. January 18. Attendance 15.

University of Washington

Electromagnetic Forces, by Leo Nedelsky, student. Short discussion of plans for the Open House. January 27. Attendance 29.

Bell Telephone System, by A. T Emerson, Pacific Telephone & Telegraph Co. Discussion of time of holding meetings next quarter. February 3. Attendance 30.

West Virginia University

Business Meeting. J. K. Gwinn elected Treasurer. February 3. Attendance 29.

The Span Across Cheat River, by G. B. Pyles; *Hollow Spun Concrete Poles*, by S. J. Donley; *Electric Arcs*, by Ivan Vannoy; *Oil Storage Tanks in California*, by J. K. Gwinn; *New Type of Turbo-Generator Insulation*, by H. V. DeJournette; *Insulating Varnishes*, by A. H. Huggins; *Advancement in the Electrical Industry in the Year 1927*, by R. J. Boone, and *Electrical Show in New York*, by F. H. Backus. Februray 10. Attendance 31.

University of Virginia

The Shield Grid Vacuum Tube, by Chalres E. McMurdo. Three-reel motion picture "Story of a V-Type Eight-Cylinder Motor." January 16. Attendance 45.

Washington University

Business Meeting. Discussion of plans for Engineers' Day to be held on or about March 17. January 12. Attendance 26.

University of Washington

Student Courses of the General Electric Company, by Mr. Means, General Electric Co. January 13. Attendance 47.

Skagit River Project, by G. E. Harney, student. January 20. Attendance 28.

Worcester Polytechnic Institute

Fifteen Months with the Westinghouse Operating Department, by D. P. Reed, '28, and

New York Telephone Company and the New England Power Company, by D. A. Calder, New England Power Co. January 23. Attendance 25.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES JAN. 1-31, 1928

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AMERICAN MEN OF SCIENCE; a Biographical Directory. Edited by J. McKeen Cattell and Jaques Cattell. 4th edition. N. Y., Science Press, 1927. 1132 p., 10 x 8 in., cloth. $10.00.

Gives brief biographies of about 13,500 men who are engaged in scientific research in America, or who have contributed to the advancement of science by teaching or writing or by work in related fields, such as the applied sciences. A useful guide to the scientific workers of the country.

APPLIED MAGNETISM.

By T. F. Wall. N. Y., D. Van Nostrand Co., 1927. 262 pp., diagrs., 10 x 8 in., cloth. $8.00.

In view of the wide and increasing industrial importance of magnetism, there is need for a concise, yet reasonably complete, survey of this branch of electrical engineering, which this book is designed to meet. The first part presents the principles of applied magnetism and includes the theory of permanent magnets, the characteristics of magnetic substances, reductivity, magneto-striction, the electron theory of magnetism and the generation of very intense magnetic fields. Part two considers methods of magnetic testing, giving a representative selection, including those most likely to be useful in practise.

A. S. T. M. STANDARDS, issued triennially. 1927; Pt. 1, Metals. Pt. 2, Non-metallic Materials.

American Society for Testing Materials. Philadelphia, 1927. 2v., illus., diagrs., tables, 9 x 6 in., cloth. $14.00; half-leather, $17.00; vols. sold separately—cloth, $7.50; half-leather, $9.00.

This edition is one-half larger than that of 1924, the date of the last triennial revision, and contains a large number of new standards. There are now 147 standards relating to metals and 206 to non-metals.

The standards include specifications, methods of test, definitions and practises. A wise variety of commercial products of importance is covered, including materials for machinery, building and electrical equipment, road materials, fuels, lubricants and oils, preservative coatings, etc.

BONBRIGHT SURVEY OF ELECTRIC POWER AND LIGHT COMPANIES OF THE UNITED STATES. 4th edition. N. Y., McGraw-Hill Publishing Co., 1927. 173 pp., maps, 11 x 9 in., paper. $10.00.

The Bonbright survey is a geographic survey of the electrical supply industry in this country, in which every operating company is definitely connected, by maps and tables, with the communities that it serves. It enables the user to ascertain what company serves any town of over 2500 population and to obtain a picture of the surrounding territory and neighboring companies. The capitalizations and earnings of the larger companies are included, with certain relevant facts about each state.

CHEMISTRY OF WATER AND SEWAGE TREATMENT.

By Arthur M. Buswell. N. Y., Chemical Catalog Co., 1928. (American Chemical Society. Monograph series). 362 pp., illus., diagrs., tables, 9 x 6 in., cloth. $7.00.

Aims to give a complete summary of the existing information upon the chemical reactions taking place in the various processes by means of which water is improved for domestic and industrial use and waste liquors are rendered fit to be discharged into water courses. It is, the author states, the only book dealing solely with the chemistry of the various purification processes at present applied to water and sewage.

COURS DE MECANIQUE; Complément.

By L. Guillot. Paris et Liége, Ch. Béranger, 1926-1927. 2 v., illus., diagrs., 9 x 6 in., paper. Price not quoted.

These pamphlets supplement the treatment of the resistance of reinforced concrete and upright beams, and of the special mechanics of fluids given in the author's treatise on mechanics, published some years ago.

COURSE OF MODERN ANALYSIS.

By E. T. Whittaker and G. N. Watson. 4th edition. Cambridge, University Press; N. Y., Macmillan Co., 1927. 608 pp., 11 x 8 in., cloth. $12.50.

An admirable treatise, which gives a rather exhaustive account of the various ramifications of the subject, for use by advanced students and for reference. References to the literature are numerous. The changes from the third edition consist in additional references and corrections of errors.

DESIGN OF MERCHANT SHIPS AND COST ESTIMATING.

By Alexander Kari. Lond., Crosby Lockwood & Son, 1927. 299 pp., diagrs., tables, 10 x 7 in., cloth. 36s.

This, the author says, is the first attempt to treat the practical side of design and cost in a systematic manner. The author gives no space to the theory of naval architecture but confines himself to the problem of designing, for the lowest cost, the ship which will perform a specific service most economically. For this purpose he discusses such questions as the choice of the type of hull, the determination of dimensions, the general arrangements for particular trades, etc. The latter half of the book discusses the estimating of weights and costs and gives formulas and methods for preliminary calculations. Numerous coefficients and formulas are given throughout the text.

DIELECTRIC PHENOMENA; Electrical Discharges in Gases.

By S. Whitehead. N. Y., D. Van Nostrand Co., 1927. 176 pp., diagrs., 9 x 5 in., cloth. $4.00.

This volume presents a critical summary, written from the scientific point of view, of the available knowledge upon the phenomena accompanying electrical discharges in gases. It gives a short account of the main phenomena that have been observed in discharges at pressures for which the mean free path is small in comparison with the dimensions of the electrodes, and discusses briefly the theories dealing with them. The volume has been prepared at the suggestion of the Electrical Research Association, to encourage study of the fundamental phenomena of insulators.

DIESELMASCHINEN; Grundlagen, Bauarten, Probleme.

By Julius Magg. Berlin, V. D. I. Verlag, 1928. 278 pp., illus., plates, diagrs., port., 12 x 9 in., cloth. 26.-r. m.

The aim of this book is to provide a general survey of our knowledge of the theory and construction of the Diesel engine, and of the trend of future development, which will be as concise as possible and yet be reasonably full and comprehensive in scope.

The first section presents the fundamental principles of the engine, treating of its thermodynamics and thermometry, the calculation of the principal dimensions, its fuels and its economy and power. The second section discusses design. It describes and illustrates the various types, presenting numerous models that have not been published previously. Chapters are devoted to locomotives, automobiles, and ship propulsion.

In the third section the author discusses unsettled and unsolved problems in design, using the unpublished results of his own experimental work. A new theory of scavenging in two-cycle engines is presented, and its practical uses shown. The use of exhaust-gas turbines is examined critically.

ELECTRIC CONTROL GEAR AND INDUSTRIAL ELECTRIFICATION.

By William Wilson. N. Y., Oxford University Press, American Branch, 1927. 361 pp., illus., tables, 9 x 6 in., cloth. $8.50.

A comprehensive treatment of electrical control gear as used in industry. The author first discusses the design, arrangement and construction of controlling apparatus, considering first the individual items, and then their association and combination to form complete schemes with any desired characteristics. Typical installations in the principal departments of industrial work, such as steel mills, hoisting, cranes, machine tools, and textile and printing plants, are then described.

ELECTRIC WINDERS.

By H. H. Broughton. Lond., Ernest Benn, Ltd., 1927. 402 pp., illus., diagrs., tables, 11 x 9 in., cloth. 52s 6d.

The primary purpose apparently is to provide the mining engineer with a comprehensive account of the practical possibilities of electric hoisting. The appliances used are described exhaustively, with numerous examples of their practical application and many useful data upon performance, cost of operation, life, etc. The book will also be useful to designers and builders of electric hoisting machinery, as a convenient reference book.

ELECTRICAL POWER TRANSMISSION.

By E. A. Loew. N. Y., McGraw-Hill Book Co., 1928. 388 pp., diagrs., charts, tables, 9 x 6 in., cloth. $4.00.

A treatise upon the theory and design of electric transmission lines. Starting with an extended discussion of the mathematical tools and the underlying circuit theory of the transmission lines, the author then proceeds to study the mechanical features of the design, the influence of mechanical and electrical features upon its economics and, finally, to illustrate the theory and principles previously developed, by applying them to a hypothetical problem.

DIE ELEKTRISCHE TELEGRAPHIE MIT DRAHTLEITUNG, v. 2; Die Typendruck-telegraphen.

By J. Herrmann. Ber. u. Lpz., Walter de Gruyter & Co., 1927. 126 pp., illus., diagrs., 6 x 4 in., cloth. 1,50 r. m.

Gives a brief, yet comprehensive, description of the various printing telegraph systems in use in Germany.

ELEMENTARY BUILDING SCIENCE.

By Alfred Everett. N. Y. & Lond., Oxford University Press, 1927. 159 pp., diagrs., 9 x 6 in., cloth. $2.50.

This is not a book on building, but an elementary book on physics and chemistry with reference to their applications to building and building materials and related problems. The text covers such subjects as water pressure, heat, combustion, oxygen and its action on metals, gaseous fuels and water. The treatment is simple and adapted to the needs of trade schools. Laboratory exercises are included. The purpose is to equip the student for the intelligent study of building problems in general.

ELEMENTS OF MACHINE DESIGN, Pt. 1.

By W. Cawthorne Unwin and A. L. Mellanby. New edition. N. Y., Longmans, Green & Co., 1927. (Textbooks of Science). 531 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

Unwin's Machine Design is so widely known that no comment upon its plan and scope is necessary. Since its first appearance, fifty years ago, it has remained a favorite text on its subject. The new edition shows no great change in scope and arrangement over the preceding one, but Professor Mellanby has altered and rewritten such parts of the text as no longer represented modern practice, and has added new matter when it was necessary.

ENGINEERING OF POWER PLANTS.

By Robert H. Fernald and George A. Orrok. 3d edition. N. Y., McGraw-Hill Book Co., 1927. 663 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.50.

This work, intended primarily as a text-book for students of all branches of engineering, is an epitome of modern practice. The authors emphasize the fact that engineering is an art, not an exact science, and also stress the commercial aspects of the subject. Steam, gas, compressed air, and water power are discussed. The new edition incorporates the developments in the production of power during the last five years.

GUIDE TO THE LITERATURE OF CHEMISTRY.

By E. J. Crane and Austin M. Patterson. N. Y., John Wiley & Sons, 1927. 438 pp., illus., 9 x 6 in., cloth. $5.00.

This book will be of great assistance to every one facing the task of searching for specific information in the vast mass of chemical literature. It classifies the various sources of information, explains the peculiarities and limitations of the important periodicals and books of reference and gives sound counsel upon their use and the art of searching. Many useful biliographies and tables are included. Although intended for chemists, the methods are equally adapted to all searching, and many engineers will find the work of distinct help.

GUMMIFREIE ISOLIERSTOFFE. Edited by Arthur Sommerfeld. Berlin, Zentralverband der deutschen elektrotechnischen Industrie, 1927. (Julius Springer, distributor). 103 pp., illus., diagrs., tables, 8 x 6 in., paper. 2,80 r. m.

Discusses the manufacture, properties, testing, construction and uses of molded electrical insulators of other plastics than rubber. The technology of their manufacture is described briefly, yet clearly, and the necessary machinery illustrated. The authors are all actively engaged in the industry.

HANDBUCH DES BERATENDEN INGENIEURS.

By S. Herzog. Stuttgart, Ferdinand Enke, 1925. 519 pp., 10 x 7 in., paper. 20.-mk.; bound, 22,50 mk.

A treatise upon the work of the consulting engineer, particularly one engaged in the investigation of manufacturing and industrial enterprises. Apparently the first attempt to present in systematic fashion the general principles upon which such investigations should be based.

After an introductory account of the evolution of the consulting engineer, his duties are discussed. Sketches and plans are then discussed, after which the various duties of the consultant, technical, statistical, commercial and financial, are treated, both with reference to existing industries and new projects. Numerous examples of the practical application of the methods are included.

HANDBUCH FUR EISENBETONBAU. Edited by F. Emperger. v. 12. Dachbauten, Schalen und Rippenkuppeln, by H. J. Kraus and Fr. Dischinger. 3d edition. Berlin, Wilhelm Ernst & Sohn, 1928. 378 pp., illus., diagrs., tables, 11 x 8 in., paper. 25,50 r. m.

This volume of the handbook treats of the design and construction of reinforced concrete roofs, domes and vaulting. A thorough treatment of the topics is given, both with respect to theory and modern practise. Numerous illustrations of actual structures are included.

HISTORY OF THE GREAT WESTERN RAILWAY, v. 1, 1833-1863, pt. 1-2.

By E. T. MacDermot. Lond., Great Western Railway Co., 1927. 2 v., illus., ports., maps, 9 x 6 in., cloth. 21 s.

A comprehensive history of this great English railroad, which gives in detail an account of its inception, construction, and economic and engineering vicissitudes. The "gauge war" is described at length, and there are interesting chapters on the development of signals, train service, operating methods, and on cars, and locomotives, the last two subjects being treated by the late E. L. Ahrons. The book is well illustrated. Of interest to every student of railroad history.

Introduction Generale a La Photometrie.

By Charles Fabry. Paris, Revue d'Optique théorique et instrumentale, 1927. (Encyclopédie Photométrique, v. 1). 178 pp., diagrs., tables, 9 x 6 in., paper. 20 fr.

The Revue d'Optique has undertaken the publication of a photometric encyclopedia composed of some twenty-seven volumes, each of which will deal with a definite aspect of the broad subject of the measurement of the intensity of visible or invisible radiation.

The present volume, by the Director of the Institute of Theoretical and Applied Optics, presents the fundamental ideas, the definitions, and the units used in measuring radiant energy; and forms a general introduction to the volumes which are to follow.

Introduction to the Metallurgy of Iron and Steel.

By H. M. Boylston. N. Y., John Wiley & Sons, 1928. 571 pp., illus., tables, 9 x 6 in., cloth. $5.00.

A well illustrated, well written text-book upon the manufacture of iron and steel, as now carried on in America, which covers the entire industry without attempting to be exhaustive. Professor Boylston gives particular attention to the winning of the metal from its ores and the processes for refining it to the desired quality, and gives less space to processes of shaping steel and to metallography and heat treatment. The book is intended as a college text-book, but is also suitable for those with only a general interest in the subject.

James Watt and the Steam Engine.

By H. W. Dickinson and Rhys Jenkins. Oxford, Clarendon Press; N. Y., Oxford University Press, 1927. 415 pp., illus., ports., 11 x 9 in., cloth. $21.00.

This handsome volume, one of the results of the commemoration of the centenary of Watt's death, at Birmingham in 1919, will be valued by every student of the steam engine and of invention. It is the definitive work upon the labors of Watt, based upon first hand study of the documents by two men with unusual qualifications for the task.

The book is divided into two parts, dealing respectively with the man and with his work upon the steam engine. The biographical section is comparatively brief. It gives salient facts about his life, correcting some erroneous views that have been held until now. The second, and larger, section discusses critically the origin of his invention, the steps by which it was reduced to a practical form and the development of the steam engine under his direction.

The book is elaborately illustrated with portraits, and with photographs from the original Boulton and Watt drawings. A critical bibliography is included.

Lectures on Theoretical Physics, v. 2.

By H. A. Lorentz. N. Y. & Lond.; Macmillan & Co., 1927. 410 pp., 9 x 6 in., cloth. 21s.

This volume, which is uniform with volume one, contains a translation of four courses of lectures on theoretical physics, which have previously been published in Dutch during the years 1919 to 1926. These courses are upon thermodynamics, entropy and probability, the theory of radiation, and the theory of quanta.

Manual of Industrial Safety.

By Sidney J. Williams. Chic. & N. Y., A. W. Shaw Co., 1927. 197 pp., 9 x 6 in., cloth. $2.50.

On the basis of his twenty years of experience with the Wisconsin Industrial Commission and the National Safety Council, the author has prepared this exposition of the essentials of safety work as a handbook for safety engineers and managers. It discusses the works' safety organization, the training of employees, safety equipment, hazards, fire prevention, health, accidents and related topics, giving sufficient information to lead to the sources of complete descriptions of methods and practise.

Molecular Physics and the Electrical Theory of Matter.

By James Arnold Crowther. 4th edition. Phila., P. Blakiston's Son & Co., 1927. 202 pp., illus., diagrs., tables, 8 x 5 in., cloth. $2.50.

Progress in the investigation of the properties and structure of the atom has been so rapid that Dr. Crowther has been obliged again to rewrite his admirable survey of the electrical theory of matter. The new edition extends the previous account by including the new developments. It can be warmly recommended as a coherent, intelligible account of work upon its subject and of present theories.

Les Moteurs a Courants Alternatifs.

By Louis Lagron. Paris, Albert Blanchard, 1927. 429 pp., illus., diagrs., 7 x 5 in., paper. 25 fr.

A text-book on the theory, design and construction of these motors, covering the ground usually covered by a college text.

The Phase Rule and its Applications.

By Alexander Findlay. 6th edition. N. Y., Longmans, Green & Co., 1927. (Text-books of physical chemistry). 326 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.50.

A non-mathematical explanation of the principles underlying the Phase Rule, with illustrations of their application to the classification and investigation of cases of chemical equilibrium. The book is intended for students of physical chemistry, metallurgy and geology, and aims to be elementary enough for the beginner of the subject. This edition has been altered extensively and carefully revised throughout.

Pioneers of Wireless.

By Ellison Hawks. Lond., Methuen & Co., 1927. 304 pp., illus., ports., 9 x 6 in., cloth. 12/6.

After giving an account of the researches of the early students of electricity, who laid the foundation upon which the art of wireless is based, the author discusses the development of methods by conduction and by induction down to the invention of the thermionic valve. The result is a history which begins with William Gilbert and traces its subject to recent times, calling attention to many men whose work is frequently overlooked or undervalued.

Practical Radio Telegraphy.

By Arthur R. Nilson and J. L. Hornung. N. Y., McGraw-Hill Book Co., 1928. 380 pp., illus., diagrs., 8 x 6 in., cloth. $3.00.

A well balanced text-book, prepared for training radio operators, and covering the knowledge necessary to obtain licenses. It is also adapted for use as a reference book by those charged with the maintenance of the types of equipment discussed. Covers radio telegraphy as used in the marine services.

Proceedings of the 13th Annual Meeting, 1927.

American Society for Testing Materials. Philadelphia, 1927. 2 v., illus., diagrs., tables, 9 x 6 in., cloth. $6.50; half-leather, $8.00; paper, $6.00.

The proceedings are issued in two parts. The first contains reports of the 48 committees charged with the preparation of various standards, together with 88 tentative standards, which were submitted or revised at this meeting. Part two contains 33 papers presented at the meeting. These describe investigations of the properties of metals and of methods for testing metals, of cement and concrete, of asphalts, and of rubber.

Radiotechnik, v. 5; Die Elektronen-Röhre.

By Otto Stürner. Ber. u. Lpz., Walter de Gruyter & Co., 1927. 124 pp., illus., diagrs., 6 x 4 in., cloth. 1,50 r. m.

A concise text upon vacuum tubes, their manufacture, properties, uses and modes of action.

Short History of Physics.

By H. Buckley. N. Y., D. Van Nostrand Co., 1927. 263 pp., 8 x 5 in., cloth. $3.00.

A historical account of the development of physics from its earliest origins to the present day. The author has had in mind the needs of the general reader and the scientist who is not a specialist in physics, and has attempted to supply a simple, yet exact account which is not overburdened with detail. He traces successfully the development of present theories from the successes and failures of earlier investigators and gives a good survey of the subject.

Thermionic Phenomena.

By Eugène Bloch. N. Y., E. P. Dutton & Co., 1927. 145 pp., diagrs., tables, 7 x 5 in., cloth. $2.50.

A discussion of the phenomena of electrical conductivity exhibited in the neighborhood of substances which are raised to a sufficiently high temperature. The author gives a concise, clear review of the experimental work in this field and of the theoretical conclusions that have been accepted, as well as an account of the industrial applications of the phenomena.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contributions from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W. V. Brown, Manager.
53 West Jackson Blvd., Room 1736, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 West 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription rate of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

UNDERGROUND DISTRIBUTION ENGINEER, 30-35, technical graduate, having considerable initiative, ability and experience on design and construction of a-c. underground systems. Apply by letter, giving complete information, as to age, education and experience. Permanent. Location, New York. X-3540-C.

SHOP MANAGER, graduate mechanical engineer, 35-40, with up-to-date shop experience, for company manufacturing all kinds of electric equipment, such as telephone apparatus, cables, lights, etc. Must be experienced executive, able to redesign if apparatus is not practical. Piece rate and cost experience desirable. Apply by letter. Location, Middlewest. X-3392.

FACTORY SUPERINTENDENT, graduate electrical engineer, 40-50, with proved record for manufacturing in all its details. Good administrator experience in control of labor, costs, production, etc., as well as in control and direction of inventors, model and tool makers. Apply by letter, giving age, education, experience and actual responsibilities for last 10 years, not only by titles but by description. Company employs over 1000 hands. Product consists of devices mostly mechanical. Location, New England. Apply only by letter. X-3721-C-S.

SALES ENGINEER, to demonstrate, install, and sell gear cutting machinery. Must have this experience. Apply by letter. Permanent. Salary $65 a week. Headquarters, New York City. Traveling. X-4003.

ENGINEER, to take over line of carbon products in New York territory. Headquarters, Pennsylvania. Apply by letter. X-3007-C.

RESEARCH GRADUATE ASSISTANTSHIPS, in engineering experiment station of Middlewest university, devoting one-half time to engineering research and the remainder to graduate study. Training gives excellent preparation for engineering teaching, for engineering research and for the profession of engineering. Applications for appointment should be sent by April 1, 1928. Blanks furnished upon request. Apply by letter. Annual stipend $600 and freedom from fees. X-4156-C-S.

RADIO ENGINEER, for research and development work in receiver circuits for position with large stable radio corporation. Must have E. E. or equivalent degree and must have conducted original experimental investigations along similar lines. Apply only by letter. Location, New York City. X-2419.

MEN AVAILABLE

EXECUTIVE OR ASSISTANT, 36, married. 12 years' experience covering distribution, installation, sales, administration, purchasing, statistics, special reports. Capable, energetic, adaptable and loyal. Desires connection with engineering, manufacturing or public utility concern, where hard work and ability will be recognized. Location, Middlewest preferred. C-3616.

ELECTRICAL ENGINEER, graduate, 23, experienced in layouts, connection diagrams detailing switchboards, instrument transformer design and estimating. Desires permanent position with opportunty for advancement. Location, immaterial. C-4044.

ELECTRICAL AND MECHANICAL ENGINEER, 42, married. Technical University graduate. Sixteen years of practical experience in design, test and operation of a-c. and d-c. motors, generators; relays, contactors, controllers, switch board panels; elevator construction, hoisting equipment and installations; electric arc welding; development and production work. Location, East. B-5240.

EXECUTIVE OR ASSISTANT ELECTRICAL ENGINEER, 43, married. Well-balanced experience; 8 years power plant, substation design with electric railways, public utilities; 12 years with consulting engineer, industrial plant work covering tests, surveys, reports, design, specifications, construction supervision. Desires position with consulting engineer, architect or large industry with number of plants. Location, eastern Pennsylvania. C-4045.

COLLEGE TEACHER OR INDUSTRIAL RESEARCH ENGINEER, 33, married, M. S. in E. E., Ph. D. in Physics. Three years with General Electric Company; three years teaching electrical engineering in college; three years teaching physics in colleges. Location, West, prefer Pacific slope. C-3444-78-C-4.

ELECTRICAL ENGINEERING GRADUATE, B. S. in E. E., 23, single, year in industrial electrical maintenance and one year with natural gas company. Desires position as instructor or one in connection with high-voltage research. Location, immaterial. C-4024.

ELECTRICAL ENGINEER, 30, married, desires a permanent position in which production or development work on small electrical or mechanical parts will predominate. Ten years' engineering experience with Vickers Ltd., and Westinghouse; also street railway experience and some drafting. C-846.

MANAGER-EXECUTIVE, 42, married, technical education; four years United States Government Foreign Service, construction, operation; ten years operating executive, nationally known holding company, Interests, United States; three years Far East, foreign executive, consultant, engineer. Location, foreign or domestic. C-4036.

ASSISTANT TO ENGINEER OR SUPERINTENDENT. Electrical and mechanical engineer with nine years' experience in responsible position in the installation, testing, operation and maintenance of generating and substation equipment of large public utility. Also experienced in industrial plants and general engineering. Has initiative, ability, and can secure results. C-2456.

ELECTRICAL ENGINEER, from a well-known Middle West University, age 23, specialized in Railway Engineering, desires experience with some electrical railway concern and to represent them in the future in his home country. Location, New York or Philadelphia. C-3182.

ELECTRICAL ENGINEERING TEACHER, 28, married, desires position teaching Electrical subjects in school, college or university, west or southwest. Experience; one year General Electric Company Test, two and one-half years teaching Electrical Engineering subjects in college. Minimum salary, $2700. Now employed as assistant professor, but available on short notice. B-8062.

RECENT GRADUATE, B. S. E. E. and E. E., one year of varied experience. Employed at present, desires position in consulting engineer's office. Excellent references. Location preferred, New York City. C-4070.

ELECTRICAL ENGINEER, 33, 3½ years' public utility experience, desires position as structural or electrical draftsman. Excellent references from former employers. C-1623.

OPERATING AND TEST ENGINEER, 33, married. Experienced in the design, erection, tests and operation of substation and power house equipment; electric locomotives, shovels, mine and mill equipment; relay protection and metering; speaks Spanish. Location, United States or foreign. C-3549.

ELECTRICAL ENGINEER, 23, single. Experienced in construction of transmission lines abroad and testing of equipment. Some knowledge of power plants and some practical experience in their operation. Location, immaterial. C-4069.

GRADUATE ENGINEER, 18 months of Westinghouse Test; research and development experience; 10 months installation work on automatic substations. Employed at present but available on reasonable notice. C-4079.

ELECTRICAL ENGINEER, 25, single, to do engineering graduate work, technical or practical, preferring practical, or sales engineering. Has had four years' of practical experience with large manufacturing company testing all types of electrical control. Location preferred, Middlewest. C-3-25-1394.

ELECTRICAL ENGINEER with eleven years' broad experience in teaching and practical engineering work in manufacturing and public utility companies, wishes a professorship in electrical engineering. Holds a master's degree from a recognized eastern university, has been an associate professor for four years and seeks greater opportunities. B-7892.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, University of California. B. S. and M. S. Teaching and laboratory as well as power and industrial experience. Would like teaching or laboratory position or work involving application, control or design. Position with consulting engineer desired. Excellent references. Available end of April. Location, immaterial. C-2938.

ELECTRICAL ENGINEER, 30, married. Graduate E. E., General Electric Test 1½ years; electrician and foreman on industrial maintenance and construction 2½ years; 3½ years generating and substation construction with some experience on station operation, distribution, rates and services. Location, United States, Canada. B-7637.

ELECTRICAL ENGINEER, 24, single. Four years' experience in all departments of interurban railroad; one year as mechanical and Patent Office draftsman; two years as assistant engineer of large interurban railway system. Location preferred, United States. C-4094-1564.

ASSISTANT TO OPERATING SUPERINTENDENT, 28, married. Technical graduate; 15 months' Westinghouse course on power and railway work; 2¼ years computor on new electrification at Cleveland, Ohio; 15 months appraisal engineer on Utility in Tennessee. Desires permanent position with future. Location, East or Middlewest. C-3997-1659.

SALES SERVICE ENGINEER, 34, married, eight years service and construction, large electrical manufacturing company. Five years construction power house and substation. Wide acquaintance, central station and industrial field. Location, Chicago. C-4083.

MANUFACTURER'S REPRESENTATIVE. Wish to act as agent in Pittsburgh District for manufacturer of Electrical or Mechanical apparatus or supplies on commission basis. Electrical engineer with broad engineering experience. C-4089.

ASSISTANT TO OPERATING DEPARTMENT HEAD OF PUBLIC UTILITY or to a production manager of a manufacturing company. Three years' shop experience, machine and auto body shop; 18 months with large public utility planning and economic studies. B. E. E. in 1926. C-2819.

ELECTRICAL ENGINEER, 27, single, two years' Westinghouse training, three years public utility. Experienced in design of underground and overhead distribution systems. Location preferred, East or Middlewest. C-1298.

PLANT ENGINEER, married. Generating and industrial plant construction and operation, survey and improvement of industrial plants and manufacture, development of automatic machines and automatic control of machinery. Versatile, resourceful, capable of training men and increasing efficiency. Location, New York City or vicinity. B-7005.

EXECUTIVE REGISTERED MECHANICAL ELECTRICAL ENGINEER; New Jersey and Pennsylvania; engineering statistics, cost reduction and reorganization of industrial factories and power plants; design, construction, maintenance; steam and water power; fire protection; heating, ventilating, lighting, electric power; operating costs reduced and factories enlarged without stopping operation. Massachusetts Institute of Technology, Protestant, American. B-5714.

ELECTRICAL ENGINEER, 31, single, who has been handling large construction projects successfully. Experienced and trained in engineering management, production control and construction. Especially valuable to engineering firm or public utility. Electrical manufacturing or industrial connection considered. Location, immaterial. Salary commensurate. C-636.

GRADUATE ELECTRICAL ENGINEER AND LAWYER, certified technical patent expert, more than twenty years' experience in Patent Law, Engineering and Experting, unmarried, desires permanent position. B-7252.

TECHNICAL GRADUATE of Pratt Institute of Science and Technology, 1926; 23, single, has had four years' practical experience in sub and generating station operation and maintenance work; desires permanent position with public utility or manufacturing company dealing in electrical material. Location, New York or vicinity. C-3909.

ELECTRICAL ENGINEER, 28, married. One year construction, two years electrical engineer with manufacturer, past two years instructor in electrical engineering at State University. Desires permanent connection with engineering or industrial concern or public utility. C-1073-73-C-1-San Francisco.

RADIO-VACUUM TUBE ENGINEER, 35, married. Degrees of B. E. E. and M. S. in Physics. Three years in transformer design, last four and one-half years receiving tube design and development, including life tests and performance in close coordination with receiving set design. Familiar with tube manufacture and their application to circuits. B-1862.

SALES AND GENERAL MANAGER, 33, married, college. Familiar business organization sales, manufacturing, engineering departments. Five years sales and assistant in charge sales promotion large Public Utilities, Industrials, etc., in territory east of Rockies; later in Chicago. Five years engineering and manufacturing departments General Electric Company. Interested in administrative duties. C-4112.

DISTRIBUTION ENGINEER, 32, married. Eight years' experience two large public utilities, desires connection with public utility, preferably in Ohio or Midwestern state. Broad overhead distribution experience; complete charge last four years revamping 25 systems serving towns or small cities 5000 to 25,000 population. Also underground transmission, small outdoor substation design experience. C-4021.

MANUFACTURING EXECUTIVE, A. S. M. E. and A. I. E. E., 45, married. A mechanical and electrical engineer who has had marked success taking charge of a new product to be manufactured, developing material and labor saving equipment and putting into full operation, supervising all details of economical production and marketing. Location, East preferred. C-2406.

ELECTRICAL ENGINEER wants position in electrical field. Wide experience in engineering, manufacturing, sales, erection and operation of storage batteries. Graduate of Massachusetts Institute of Technology in Electrical Engineering. C-4109.

ELECTRICAL ENGINEER with twenty years' experience in making surveys, designs and supervising the construction of underground distribution systems. Has been exceptionally successful on recent Three-Phase-Four wire systems on underground distribution. Individual surveys and designs considered on a monthly salary basis. Highest references from leading engineers. B-4272.

ELECTRICAL ENGINEER, single, seven years' experience. Executive experience with contractors as designer of electrical and mechanical layouts, writer of specifications for schools, office buildings, hospitals and theaters. Broad knowledge of electrical and mechanical equipment, supervision of installations of such equipment, General Electric test course. Desires permanent position with good future. C-2268.

GRADUATE ELECTRICAL ENGINEER, 25, two years' experience in cable and substation work, wants connection with utility or mining company. Location, immaterial. C-2449.

ELECTRICAL ENGINEER, 26, single, M. S. '25, cooperative course Massachusetts Institute of Technology and General Electric Company. One year general Electric design, two years large eastern utility, engineering and distribution departments, transmission line studies, estimating, inspection and maintenance. Desires position with contracting, engineering or utility company. Middle West preferred. Highest references. C-4043

GRADUATE ELECTRICAL ENGINEER, 28, married; two years' experience in meter and service work as foreman. Wishes to obtain position in the Distribution Department of large public utility where there is chance for advancement. Location preferred, Middlewest or South. C-4073.

ELECTRICAL ENGINEER, 41, married, Scandinavian, graduate of technical college, B. S., 9 years in United States. Varied experience in design of electrical and mechanical apparatus. Capable of developing ideas. Also experienced in power houses and substations. Thorough education, knows several languages, including Spanish. Willing to travel, but work along theoretical lines preferred. C-216.

ELECTRICAL ENGINEER, 48. Varied experience in construction maintenance of industrial plants and textile mills including the up-keep of cranes, elevators, remote control, welder and magnets. Design and manufacturing of controllers, motors for industrial trucks and tractors; also locomotives for mine work; in charge of department for 12 years. Location preferred, East or Great Lake region. C-4128.

GRADUATE ELECTRICAL ENGINEER, 25, single, one year out of Cornell. Desires work on station design, transmission or distribution. Six seasons of technical experience including one season of high line maintenance; also one year of station design. Location preferred, New York State or vicinity. C-4129.

EXECUTIVE ENGINEER OR MANAGER, 44, five years college, seeks responsible position where 24 years' experience in the industry would appeal. Many years Westinghouse and Crocker Wheeler, and chief engineer for two smaller concerns. Five years departmental manager in complete charge of motor production, engineering and shop. Also sales experience. Unusually broad outlook. C-30.

PUBLIC UTILITY ENGINEER, 31, married. Experienced in gas and electric utility operation and development. Costs and rates, public relations, power sales, merchandising, organization routine, economics, etc., desires position as assistant to commercial or general executive to take charge of details. Location, South or West preferred but immaterial. C-4132.

ELECTRICAL ENGINEER, with broad experience in design and manufacture of small electrical apparatus and instruments. Thoroughly familiar with design, practical manufacture and application of such products. Experienced executive capable of building up new or improving old organizations. Expert in developing manufacturing methods and processes, standardization, and quantity production. American, Christian. B-2721.

MEMBERSHIP — Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held February 8, 1928, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

LITTLETON, JESSE T., Chief, Physical Laboratory, Corning Glass Works, Corning, N. Y.

To Grade of Member

BASSETT, WALTER G., Chief Engineer, Cady Lumber Corp., McNary, Ariz.

BLACK, JOHN C , Supt., Southwest Power Co., Rogers, Ark.

BROWN, MICHAEL J., Electrical Engg. Dept., Brooklyn Edison Co., Brooklyn, N. Y.

CONNELL, LAWRENCE H., Research Engineer, Detroit, Edison Co., Detroit, Mich.

GAMBLE, LESTER R., Asst. Elec. Engr., Washington Water Power Co., Spokane, Wash.

GRAYSON, ALFRED CLARK, Supt. Elec. Constr., Public Service Production Co., Newark, N. J.

HOCKADAY, OLIN S., Transmission Supt., Texas Pr. & Lt. Co., Dallas, Texas.

HUANG, THEODORE S., Electrical Designer, Stone & Webster, Inc., Boston, Mass.

JOHANSSON, KARL W., Switchboard Engineer, Westinghouse E. & M. Co., East Pittsburgh. Pa.

JOHNSON, RICHMOND C., Electrical Engineer, 2638 Cleveland Ave., Kansas City, Mo.

LEE, EVERETT S., In charge, Insulation Division, General Elec. Co., Schenectady, N. Y.

LOGAN, HENRY, Engineering Consultant, Holophane Co., New York, N. Y.

MILLS, EDWARD A., Supt. of Power, Tenn. Copper Co., Copperhill, Tenn.

PAWSON, HERBERT E., Asst. Commercial Mgr., Power Corp. of Canada, Ltd., Montreal, Que., Can.

PERRY. IRVING D., Engg. Asst., Public Service Production Co., Newark, N. J.

READY, WILLIAM A., President and General Manager, National Co., Inc., Cambridge, Mass.

SENAUKE, ALEXANDER, Assistant Director, Popular Science Institute, New York, N. Y.

SHANCK, ROY B., Engineer, American Tel. & Tel. Co., New York, N. Y.

SISSON, CHARLES E., Transformer Engineer, Canadian General Elec. Co., Toronto, Ont., Can.

STRONG, ELMER E., Vice-President, Schiefer Elec. Co., Inc., Rochester, N. Y.

SWAN, GEORGE L., Engineer, National Board of Fire Underwriters, New York, N. Y.

TENNYSON, ALFRED L., Supt. of Engg., Rio de Janeiro Tramway Lt. & Pr. Co., Rio de Janeiro, Brazil, S. A.

TERRY, CLARK A., Supt., Sherman Island Hydro-Electric Development, Glens Falls, N. Y.

WOOD, HARRY G., District Engineer, Westinghouse Elec. & Mfg. Co., New York, N. Y.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before March 31, 1928.

Alexander, A. M., Hub Engineering Co., New York, N. Y.

Allen, R. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Anderson, G. D. E., Canadian Westinghouse Co., Ottawa, Ont., Can.

Araldsen, O., Brooklyn Edison Co., Brooklyn, N. Y.

Armitage, L. C., 207 Grand Ave., Brooklyn, N. Y.

Aro, I. N., General Electric Co., Philadelphia, Pa.

Atkinson, R. G., Public Service Co. of Colorado, Denver, Colo.

Auger, P. E., Bell Telephone Laboratories, New York, N. Y.

Augur, J. M., Westinghouse Elec. & Mfg. Co., Hartford, Conn.

Ball, M. T., Bull Dog Electrical Products Co., Grand Rapids, Mich.

Becker, C. T., Brooklyn Edison Co., Brooklyn, N. Y.

Billings, C. P., (Member), Electric Bond & Share Co., New York, N. Y.

Bronson, R. O., Erie Lighting Co., North East, Pa.

Browne, K. A., Cornell University, Ithaca, N. Y.

Brundage, H. F., School of Engineering of Milwaukee, Milwaukee, Wis.

Burns, D. G., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.

Burr, G. W., Bell Telephone Laboratories, New York, N. Y.

Bush, R. M., Virginia Electric & Power Co., Petersburg, Va.

Byrne, R. W., White Metal Trust Co., Los Angeles, Calif.

Carneiro, U. G., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Carpenter, W. W., (Member), Bell Telephone Laboratories, New York, N. Y.

Charlesworth, G., Iowa Railroad Commission, Des Moines, Iowa

Chester, F. E., (Member), Philadelphia Electric Co., Philadelphia, Pa.

Chin, L. C., United Electric Light & Power Co., New York, N. Y.

Christopher, A. J., Bell Telephone Laboratories, New York, N. Y.

Ciarelli, P. F., New York Edison Co., New York, N. Y.

Clyde, J. P., Public Service Co. of No. Illinois, Chicago, Ill.

Collins, J., Public Service Production Co., Newark, N. J.

Connolly, J. P., Hoffman & Elias, New York, N. Y.

Consolver, P., Illinois Power & Light Corp., Chicago, Ill.

Copenhaver, P. S., Western Union Telegraph Co., New York, N. Y.

Costa, A., T. F., Jones & Co., New York, N. Y.

Cox, V. L., General Electric Co., Philadelphia, Pa.

Creasey, W., So. California Edison Co., Long Beach, Calif.

Crittenden, R. E., Public Service Electric & Gas Co., Newark, N. J.

Curran, W. R., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Curtis, F., Southern Sierras Power Co., Riverside, Calif.

Dean, G. E., Public Service Electric & Gas Co., Newark, N. J.

Dempster, E. R., Jensen Radio Mfg. Co., Oakland, Calif.

Derrick, C. L., Public Service Electric & Gas Co., Newark, N. J.

Dowd, A. J., Western Electric Co., Kearny, N. J.

Durgin, M. F., Charlestown High School, Charlestown, Mass.
(Applicant for re-election.)

Dusinberre, C., School of Engineering of Milwaukee, Milwaukee, Wis.

Engh, H. M., Mutual Telephone Co., Erie, Pa.

Enssor, B. H., Waldrich Bleachery, Delawanna, N. J.

Evangel, C. E., Mountain States Tel. & Tel. Co., Denver, Colo.

Evenden, F. R., Public Service Production Co., Newark, N. J.

Farrow, F. R , Jr., Victor Talking Machine Co., Camden, N. J.

Fatum, C. H., Public Service Production Co , Newark, N. J.

Feather, A. M., Texas Louisiana Power Co , Fort Worth, Texas

Fennis, A. M., English Electric Co., St. Catharines, Ont., Can.

Fieneman, C., Safety Cable Co., Bayonne, N. J.

Finley, S. R. G., (Member), Ohio Public Service Co., Mansfield, Ohio

Fisher, B. F., Mountain States Tel. & Tel. Co., Denver, Colo.

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Ford, L. O., Condit Electric Mfg. Corp., New York, N. Y.

Forrest, E. F., Standard Dental Mfg. Co., Philadelphia, Pa.

Francesco, A., Brooklyn Edison Co., Brooklyn, N. Y.

Freeman, R. B., Columbia Power Co., Columbia Park, Ohio

Frey, H. A., Locke Insulator Corp., Baltimore, Md.

Gartner, H. C., Union Gas & Electric Co., Cincinnati, Ohio

Gates, R. H., Century Electric Co., St. Louis, Mo.

Given, F. J., Bell Telephone Laboratories, New York, N. Y.

Glenn, H. H., (Member), Bell Telephone Laboratories, New York, N. Y.

Gliddon, W. G. C., Gatineau Power Co., Ottawa, Ont., Can.

Goetz, M. T., Illinois Inspection Bureau, Joliet, Ill.

Goodridge, W., General Electric Co., Philadelphia, Pa.

Gourley, T. S., Brown Instrument Co., Philadelphia, Pa.

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Hemker, W. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Hidy, J. W., New York Edison Co., New York, N. Y.
Hilbert, W. F., Edison Elec. Illuminating Co. of Boston, Boston, Mass.
Hironaka, K., Mitsui & Co., Ltd., New York, N. Y.
Hoff, H. C., Commonwealth Edison Co., Chicago, Ill.
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Hunlon, L. F., British Columbia Pulp & Paper Co., Port Alice, B. C., Can.
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Lakos, A., Brooklyn Polytechnic Institute, Brooklyn, N. Y.
Le Barron, G. I., Eureka Copper Products Co., North East, Pa.
Leitch, D., Jr., Philadelphia Electric Co., Philadelphia, Pa.
Lipka, R., S. Cooper & Co., New York, N. Y.
Louderback, C. A., 111 Buena Vista Ave., San Francisco, Calif.
Loveless, C. A., New Street Lighting Div., City of St. Louis, St. Louis, Mo.
Martin, W. S., Brooklyn Edison Co., Brooklyn, N. Y.
Mason, J. E., Central Power & Light Co., San Benito, Texas
Mauk, C. E., Ralph E. Phillips Co., Los Angeles, Calif.
McDowell, C. C., General Electric Co., Buffalo, N. Y.
McKenna, J. F., Barker & Wheeler, New York, N. Y.
McKenzie, W. S., International Nickel Co. of Canada, Creighton Mine, Ont., Can.
McKinney, W. G., Alberene Stone Co., New York, N. Y.
McTear, C. K., Stone & Webster, Inc., Boston, Mass.
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Mirsky, J. S., Mexican Tel. & Tel. Co., Mexico, D. F. Mex.
Morrison, P. A., Ohio Boxboard Co., Rittman, Ohio
Munro, C. C., Bell Telephone Laboratories, New York, N. Y.
Newman, H. A., Acme International X-Ray Co., Chicago, Ill.
Nigrelli, R., Electrical Engineer & Contractor, Mystic, Conn.
Norcross, F., Home Gas & Electric Co., Greeley, Colo.
Parkins, A. W., Acme International X-Ray Co., Chicago, Ill.
Pawlicki, E., Defoe Boat & Motor Works, Bay City, Mich.
Peple, G. A., Jr., Wiley & Wilson, Richmond, Va.
Pfatteicher, E. P., Jr., Philadelphia Electric Co., Philadelphia, Pa.
Phillips, L. I., General Electric Co., Pittsfield, Mass.
Picatti, G. G., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Pickup, R. A., Northwestern Electric Service Co. of Pa., Meadville, Pa.
Pon, S. K., East Bay Water Co., Oakland, Calif.
Powell, H. E., Bell Telephone Laboratories, New York, N. Y.
Prior, F. W., Electrical Engineer, Toronto 6, Ont., Can.
Pronovost, J. E., Westinghouse Elec. & Mfg. Co., Bridgeport, Conn.
Quick, D. M., Public Service Electric & Gas Co., Newark, N. J.
Reyes, F. G., (Member), Electrotechnic Section, Dept. Weights & Measures, Mexico D. F., Mex.
Richman, E., Brooklyn Edison Co., Brooklyn, N. Y.
Robinson, E. L., Crescent Insulated Wire & Cable Co., Trenton, N. J.
Rohrer, P. R., The Milwaukee Elec. Railway & Light Co., Milwaukee, Wis.
Rosenquest, H. A., Bronx Gas & Electric Co., New York, N. Y.
Rowe, E. E., Des Moines Electric Light Co., Oskaloosa, Iowa
Ryan, E. A., Safety Cable Co., Bayonne, N. J.
Saliba, G. J., Brooklyn Edison Co., Brooklyn, N. Y.
Schlaikjer, H. C., Brooklyn Edison Co., Brooklyn, N. Y.
Sellers, L. R., Philadelphia Electric Co., Philadelphia, Pa.
Shaffer, C. M., Pennsylvania Power & Light Co., Hazelton, Pa.
Shaffer, G. A., Underwriters' Laboratories, Chicago, Ill.
Shaver, W. W., Corning Glass Works, Corning, N. Y.
Sheehan, J. E., (Member), Houston Lighting & Power Co., Houston, Texas
Shideler, J. H., 609 E. Central Ave., Hemet, Calif.
Small, H. W., Jr., (Member), Alcoa Power Co., Ltd., Arvida, P. Q., Can.
Somerville, G. H., Bell Telephone Laboratories, New York, N. Y.
Southgate, R., Public Service Electric & Gas Co., Newark, N. J.
Starbuck, D. K., General Electric Co., Youngstown, Ohio
Stevens, G. D., Consumers Power Co., Jackson, Mich.
Stewart, J. A., So. Indiana Gas & Electric Co., Evansville, Ind.
Still, B. I., Engineering Service Corp., Houston, Texas
Stratford, F. F., Western Electric Co., Inc., New York, N. Y.
Stuart, G. S., Southeastern Underwriters Association, Atlanta, Ga.
Summers, P. M., Union Gas & Electric Co., Cincinnati, Ohio
Sweany, F. H., Bureau of Standards, Washington, D. C.
Tafel, R. E., Nachod & U. S. Signal Co.; Cheatham Elec. Switching Device Co., Louisville, Ky.
Talley, T. J., 3rd, American Tel. & Tel. Co., Philadelphia, Pa.
Taylor, L. R., Bell Telephone Laboratories, New York, N. Y.
Thompson, B. E., Monongahela West Penn Public Service Co., Sutton, West Va.
Thompson, E. V., Commonwealth Edison Co., Chicago, Ill.
Thomson, G. A., American Brown-Boveri Electric Corp., New York, N. Y. (Applicant for re-election.)
Thorsteinsson, J. B., Winnipeg Electric Co., Winnipeg, Man., Can.
Tielking, J. W., Union Gas & Electric Co., Cincinnati, Ohio
Towers, F. C., (Member), Bronx Gas & Electric Co., New York, N. Y.
Turner, H. L., Mass. Institute of Technology, Cambridge, Mass.
Van Doeren, C. A., Missouri School of Mines, Rolla, Mo.
Veltre, F. E., Jr., Baragua Sugar Co., Central Baragua, Camaguey, Cuba
Virgin, S. P., Oklahoma Gas & Electric Co., Norman, Okla.
Warren, J. E., (Member), So. Bell Tel. & Tel. Co., Atlanta, Ga.
Watson, W. S., City Water & Light Dept., Hastings, Nebr.
Weber, H. A., Bell Telephone Laboratories, New York, N. Y.
Wensley, R. J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Whitten, R. C., Agar Packing & Provision Co., Chicago, Ill.
Wolpert, F. S., Weston Electric Instrument Corp., Waverley Park, Newark, N. J.
Wright, D. H., Gibbs & Hill, New York, N. Y.
Yearborough, M. N., Public Service Production Co., Newark, N. J.
Young, T., Dixie Construction Co., Birmingham, Ala.

Total 178.

Foreign

Abell, R. H., British Thomson-Houston Co., Ltd., Rugby, Eng.
Baldwin, C. S. S., Ferguson Pailin, Ltd., Higher Openshaw, Manchester, Eng.
Bongers, G. S., Siemens (Australian) Pty., Ltd., Sydney, N. S. W.
Fujita, I., Shibaura Engineering Works, Tokyo, Japan
Greenwood, L., Rees Roturbo Mfg. Co., Wolverhampton, Eng.
Joseph, P. L., Army Clothing Factory, Shahjahanpore, U. P., India
Pollock, C. A., Research Student at Oxford, Magalen College, Oxford, Eng.
Sayeki, T., Showa Electric Power Co., Hichiken-Cho, Higashi-Ku, Nagoya City, Japan
Wild, E. E., Ferranti, Ltd., Hollinwood, Lancashire, Eng.
Malan, S. A., Electricity Supply Commission, Johannesburg, Transvaal, S. Africa

Total 10.

STUDENTS ENROLLED

Aldrich, John B., Rensselaer Polytechnic Institute
Anderson, James N., Jr., Virginia Polytechnic Inst.
Anderson, J. Stephen, University of Wyoming
Anderson, Wallace A., Rensselaer Polytechnic Inst.
Baines, Lawrence E., Virginia Polytechnic Inst.
Baldin, Lionel S., Columbia University
Beal, John D., Jr., Northeastern University
Biddle, Stratford B., Jr., California Inst. of Tech.
Blackwell, Rex P., University of Colorado
Blevins, Russell E., Oregon State College
Blunt, Attwood F., Johns Hopkins University
Boland, William I., University of Santa Clara
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Brown, George M., State College of Washington
Burrell, Gilbert, Michigan State College of Agri. & Applied Science
Caird, Philip B., Rensselaer Polytechnic Institute
Cargill, Norman V., Rensselaer Polytechnic Inst.
Casselman, Arthur L., Georgia School of Tech.
Cassidy, Edwin C., Virginia Polytechnic Institute
Cerow, Joseph A., Jr., Rensselaer Polytechnic Inst.
Clingan, Frank H., University of Michigan
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Collins, Alfred G., Virginia Polytechnic Institute
Corcoran, James P., University of Washington
Crabtree, Leonard F., Rensselaer Polytechnic Inst.
Craig, Eugene S., Eng. School of Milwaukee
Cubello, Frank D., Rensselaer Polytechnic Inst.
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Davis, Thomas M., University of Louisville
Delaney, Nick K., University of Santa Clara
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Grogran, Patrick H., Jr., Rensselaer Polytechnic Institute
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Lee, Rex E., University of Florida
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Mar, Teh-Chien, University of Washington
Marchant, Reynolds, Virginia Polytechnic Inst.
Matteson, Horace N., Pennsylvania State College
Mattos, George, University of Santa Clara
McArthur, Merritt H., University of Idaho
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Miller, Everett H., Rensselaer Polytechnic Inst.
Miller, John W., Clarkson College of Technology
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More, William E., Northeastern University
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O'Brien, Clyde F., Clarkson College of Technology
O'Donnell, Hugh W., Virginia Polytechnic Inst.
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Olberg, Leon M., University of Washington
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Peabody, William J., Georgia School of Tech.
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Pickslay, William M., Jr., Lehigh University
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Pinkerton, Lloyd, University of Washington
Pohl, Russell A., University of Washington
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Potadle, Lawrence R., University of Nebraska
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Quam, Harry L., South Dakota State College of A. & M. Arts
Rawson, Downing O., University of Colorado
Raynor, James W., University of Colorado
Reed, Raymond H., University of Nebraska
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Shafer, G. Harold, University of Nebraska
Shinohara, Motoki, Tokyo Imperial University
Sills, Earl H., University of Kansas
Slocum, Roy F., California Institute. of Tech.
Smith, C. Elliott, The Municipal University of Akron
Smith, George A., Rensselaer Polytechnic Inst.
Somers, Frank J., University of Santa Clara
Steen, Herbert N., University of Washington
Stinchcomb, Emory L., Jr., Johns Hopkins Univ.
Suter, Merle, Washington & Lee University
Taylor, E. Arthur, State College of Washington
Terrill, John B., Jr., Virginia Polytechnic Institute
Trevor, Bertram, Cornell University
Tucker, Grover G., Virginia Polytechnic Institute
Turner, Reginald B., Jr., Virginia Polytechnic Inst
Warner, Sydney E., Rensselaer Polytechnic Inst.
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Webb, Charles C., Engg. School of Milwaukee
Webb, Wilbur L., State College of Washington
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NEW CATALOGUES AND OTHER PUBLICATIONS

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Motors.—Bulletin 202, 8 pp. Describes type "T" heavy duty Reliance motors for direct current with ball and roller bearings. Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio.

Insulated Wires and Cables.—Bulletin GEA 905, 12 pp. Describes principally paper insulated, lead-covered cables, and includes numerous tables on the current-carrying capacities of such types. General Electric Company, Schenectady, N. Y.

Electric Furnaces.—Bulletin 4, 16 pp. Describes Ajax-Northrup high frequency furnaces, operating from static converters. The Ajax Electrothermic Corporation, Trenton, N. J.

Lighting Data.—Bulletin LD 107B, 44 pp., entitled "The Mazda Lamp in Projection Service," Bulletin LD 137B, 36 pp., entitled "Lighting the Home." Edison Lamp Works of General Electric Company, Harrison, N. J.

Magnetic Separator Pulleys.—Bulletin P-26, 14 pp., entitled "Magnetic Protection." Describes magnetic separator pulleys for removing scrap or tramp iron from conveyor belts. The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.

Motor and Switch.—Bulletin 153, 6 pp Describes the new Wagner split-phase motor, ⅛, $^1/_6$ and ¼ hp., and a new switch claimed to be capable of 500,000 starts and stops. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Mo.

Circuit Breakers.—Bulletins GEA 925 (12 pp.) and 926 (4 pp). Describe station oil circuit breakers of various types, 7500 to 220,000 volts. These are of new design and construction. General Electric Company, Schenectady, N. Y.

Frequency Recorder.—Bulletin 1227, 4 pp. Describes the new improved Esterline-Angus frequency recorder, an instrument for recording frequency to the accuracy made necessary by the synchronizing of plants and the interconnection of systems. The Esterline-Angus Company, Indianapolis, Ind.

Chain Drives.—Handbook entitled "Morse Silent Chain Drives." The subject of silent chain power transmission is thoroughly covered, and typical installations are illustrated. Tables giving dimensions are included, as well as list prices. Morse Chain Company, Ithaca, N. Y.

Resistors.—Bulletin 111, 8 pp. Describes the Monitor line of resistors, including three groups: edgewound, for highest current values; hexwound, for intermediate current values; smoothwound, for the lowest current values. The Monitor Controller Company, 55 E. Gay Street, Baltimore, Md.

New Westinghouse Catalog.—The new 1200 pp., 1928-30 catalog of electrical supplies presents the electrical and mechanical features for all supply apparatus and appliances manufactured by the Westinghouse Company, and in addition describes and illustrates a representative list of large motor and generating apparatus. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Penn.

Everdur.—Bulletin E-2, 16 pp. Describes "Everdur," the trade name of an alloy composed of copper, silicon and manganese, manufactured in a wide variety of forms. The constituents of the metal are carefully proportioned to give the alloy great strength, workability and excellent machining qualities, as well as high resistance to a large number of corroding agents. The American Brass Company, Waterbury, Conn.

Lifting Magnets.—Circular, 4 pp. Describes an interesting application of EC&M magnets for sweeping highways One or more such magnets are suspended from the rear end of a truck, a few inches over the roadbed, and these pick up nails and scrap iron even if buried considerably beneath the surface of the loose sand or gravel of a roadway. Various means of supplying the electric power to the road-sweeping magnets have been tried out, but the most economical method has proven to be a gasoline-driven generator mounted in the body of the truck and connecting the magnets directly to this generator. The Electric Controller & Manufacturing Company, 2700 E. 79th Street, Cleveland, Ohio.

NOTES OF THE INDUSTRY

Corning Glass Appoints Representative.—Henry M. Hughes has been appointed representative of the Corning Glass Works with headquarters in the Oliver Building, Pittsburgh, to handle only the sales of Pyrex insulators in the states of Pennsylvania, west of Harrisburg, West Virginia and certain counties in Ohio.

The Martindale Electric Company, 1254 West 4th Street, Cleveland, O., announces that six of the most popular sizes of commutator stones are being carried at the New York branch, 6 East 46th Street; and at the Los Angeles branch, 210 East 3rd Street.

The Delta-Star Electric Company, 2400 Block, Fulton Street, Chicago, Ill., has issued a new price list No. 1 describing and listing a new line of rigid stud, compression type, solderless connectors. These connectors are made in single and double bolt lug type for conductors from No. 6 to 500,000 c. m. They are furnished in Tee, Parallel and Cross Connector types.

New Wagner Electric Offices.—The Wagner Electric Corporation has opened a sales office at Houston, Texas, 1006 Washington Avenue. W. B. Arbuckle has been placed in charge. A new branch sales office has been opened at 475 West Peachtree Street, N. E., Atlanta, to cover the states of Georgia, Alabama and Florida, until recently a part of the St. Louis sales territory. Roy F. Druschky has been put in charge of the Atlanta branch office.

New Line Start Induction Motors.—A new group of squirrel-cage induction motors suitable for starting on full line voltage is being placed on the market by the Allis-Chalmers Manufacturing Company, Milwaukee. These motors are normal torque, high reactance machines and will not draw starting current in excess of the limits recommended by the Electrical Apparatus Committee of the N. E. L. A. They are built in ratings 7½ to 30 hp., 600 to 3600 r. p. m., low voltage, and are available with either sleeve or roller bearings. A magnetic switch with push button control is the only starting equipment required.

New Automatic Induction Starter.—A new automatic induction starter with two adjustable features has been announced by the Lincoln Electric Company, Cleveland. One of the adjustments is in the starting current and starting torque and is made by changing the position of the rotor in the regulator. The other adjustment is in the current at which the throw-over takes place. The throw-over in this new starter is controlled by retarding solenoid which is operated by the motor current. The claim is made that the new automatic induction starter can be mounted more easily than any on the market today.

Welded Parts on the New Ford.—The increasing use of welding in automobile manufacture is demonstrated by the fact that a large number of parts on the new Ford car are constructed by arc welding. Among these are the rear axle housing, the steering gear casing, the radius rod, the spare tire carrier, the drag link for the front axle and the axle rods. In the past few months the Ford Company has installed approximately thirty General Electric arc welding equipments for this work. Although this is considered a fair sized welding installation, it is understood that it is but a beginning of the arc welding operations planned by the Ford Company.